The Contribution of Wrist Flexion to Electrophysiological Studies in Patients with Suspected Carpal Tunnel Syndrome

Şüpheli Karpal Tunel Sendromlu Hastalarda El Bilek Fleksiyonunun Elektrofizyolojik Çalışmalara Katkısı

Mehmet ADAM,[a]
Pınar DORUK,[a]
Berrin LEBLEBİCİ[a]

[a]Department of Physical Medicine and Rehabilitation, Başkent University Faculty of Medicine, Ankara,

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Yazışma Adresi/*Correspondence:*
Mehmet ADAM
Başkent University Faculty of Medicine, Department of Physical Medicine and Rehabilitation, Adana, TÜRKİYE/TURKEY
mehmetadam@baskent-adn.edu.tr

ABSTRACT Objective: This study aims to evaluate the effect of wrist flexion on electrophysiological studies in suspected cases of carpal tunnel syndrome (CTS) when patients have already undergone routine nerve conduction studies (NCS) and difference tests and had normal results. **Material and Methods:** In this study, 27 patients (41 hands) with CTS symptoms who had previously undergone routine electrophysiological studies and difference tests and had normal results were investigated. After performing provocative wrist flexion bilaterally at a 90 degree angle for five minutes, the median nerve distal sensory latencies (DSLs), median versus radial first digit sensory latency differences, and median versus ulnar fourth digit sensory latency differences were recorded. **Results:** The mean value of the median DSL observed before the wrist flexion provocation was 2.92±0.25, and it was 2.91±0.25 ms ($p>0.05$) afterwards. The median versus the ulnar fourth digit sensory latency difference recorded before the provocation was 0.21±0.20 while it was 0.24±0.17 ms ($p>0.05$) after the procedure. There was a statistically significant difference between the two measurements for median versus radial nerve first digit sensory latency differences (0.06±0.23 ms versus 0.18±0.25 ms, $p<0.05$), but this increase was not sufficient to reach the accepted electrodiagnostic criteria for CTS diagnosis. **Conclusion:** In this study, it was concluded that patients with CTS symptoms who had undergone routine electrophysiological studies and difference tests had no additional benefit from provocative wrist flexion performed for five minutes.

Key Words: Carpal tunnel syndrome; electrophysiology; wrist

ÖZET Amaç: Bu çalışmada rutin sinir ileti çalışmaları ve fark testleri normal olan şüpheli karpal tünel sendromlu (KTS) hastalarda el bilek fleksiyonunun, elektrofizyolojik çalışmalara olan etkisini değerlendirmek amaçlanmıştır. **Gereç ve Yöntemler:** Bu çalışma KTS semptomları bulunan, rutin elektrofizyolojik çalışmaları ve fark testleri normal olan 27 hasta (toplam 41 el) üzerinde yapıldı. Beş dakikalık provokatif bilateral 90° el bilek fleksiyonunu takiben median duyusal distal latans (ddl), başparmak median-radial ddl farkı ve 4. parmak median-ulnar ddl farkları tekrarlandı. **Bulgular:** Provakasyon öncesi saptanan median sinir ortalama dsl değeri 2,92±0,25 ms idi. Provokasyon sonrası median sinir ortalama ddl değeri ise 2,91±0,25 ms idi ($p>0,05$). Dördüncü parmak median-ulnar ddl farkı değerleri provakasyon öncesi 0,21±0,20 ms ve provakasyon sonrası 0,24±0,17 ms ölçüldü ($p>0,05$). Başparmak median-radial sinirler ddl farkları iki ölçüm arasında istatistiksel olarak anlamlı fark vardı (0,06±0,23 ms ve 0,18±0,25 ms $p<0,05$). Ancak bu artış KTS tanısında kullanılmak üzere elektrodiagnostik kriter olarak kabul edilen farka ulaşmıyordu. **Sonuç:** Bu çalışmada, rutin elektrofizyolojik çalışmaları ve fark testleri uygulanan KTS semptomlu hastalarda, beş dakikalık el bilek fleksiyonu şeklindeki provokasyonun elektrofizyolojik çalışmalara etkisi bulunmadığı gösterilmiştir.

Anahtar Kelimeler: Karpal tünel sendromu; elektrofizyoloji; el bileği

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Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy and it occurs due to the compression of the median nerve in the wrist.[1] It is characterized by paresthesia, numbness or pain in

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the median nerve territory, and these symptoms have nocturnal exacerbation.[2] A careful neuromuscular examination in combination with Tinel's sign and Phalen's tests are helpful in the diagnosis of CTS.

To confirm the diagnosis, a nerve conduction study (NCS), the most common and most sensitive method of diagnosis, the grading of the severity of CTS and the evaluation of other problems are used. Various difference tests (median versus ulnar fourth digit sensory, median versus ulnar second digit motor, and median versus radial first digit sensory) can be used to increase the efficiency of the electrophysiological studies. However, NCS results are normal in 13–27% of the patients, which can be a problem in the diagnosis and follow-up of patients.[3]

After performing full wrist flexion for five minutes, median NCS and difference tests may aid in the electrophysiological diagnosis of CTS. The aim of this study was to determine whether wrist flexion performed for five minutes could aid the diagnosis in patients with CTS who had previously undergone routine electrophysiological studies and difference tests and had normal results.

MATERIAL AND METHODS

This study was performed on 27 patients (41 hands) referred to the Electromyography Clinic of Baskent University, Adana Education and Research Center, Physical Medicine and Rehabilitation (PM&R) Department. The patients had clinical presentations consistent with CTS, in at least one hand. Patients complained of wrist, forearm, or arm pain, paresthesia or numbness in the medial thumb, index, middle, and lateral half of the ring finger (median nerve territory), clumsiness of the hand, or the dropping of objects. Symptoms were most prominent during the night and often caused the patients to awaken, arise from bed, and shake their hands in an attempt to alleviate the symptoms. These same symptoms were exacerbated during ordinary activities such as driving, holding a book, holding a telephone, or working with the hands raised, especially in a flexed or extended wrist posture. A detailed clinical history along with a thorough examination and extended musculoskeletal and neurophysiological evaluations were carried out. The possibilities of the presence of upper limb disorders that could be confused with CTS were carefully investigated.

Patients were considered positive if, there were any symptoms of pain or numbness in the first, second, or third digits or, in the lateral half of the ring digit (median nerve distribution), or if there was any increase in previous symptoms after applying the test. Tinel's sign was carried out with percussion of the median nerve at the wrist. Phalen's test was assessed simultaneously on both hands, with the participants being asked to sit and rest their elbows on a table while holding both forearms in vertical alignment. At the same time, the volar surfaces were aligned medially. Participants were then instructed to allow their wrists to relax into full palmar flexion. A positive response was accepted in cases in which any pain, paresthesia, or numbness in the median distribution of the palmar hand occurred within 60 seconds or in cases in which the previous symptoms were exacerbated.

Inclusion criteria were paresthesia or pain in the median nerve territory which worsened or became more prominent at night, paresthesia or pain which was provoked during flexed or extended wrist posture, positive Tinel's sign or Phalen's tests, and normal electrodiagnostic tests which included NCS and difference tests.

Exclusion criteria included neurological conditions such as stroke, focal or generalized neuropathies, brachial plexus lesions, lesions of the medial nerve proximal to the wrist, a history of wrist surgery, trauma or corticosteroid injections for treatment of CTS, and inflammatory or rheumatologic disorders that potentially affected transcarpal conduction, for example rheumatoid arthritis or gout. Pregnancy, systemic disorders affecting peripheral nerves such as diabetes mellitus or chronic renal failure, any abnormalities found via nerve conduction studies, wasting or atrophy of thenar eminence, and weakness of thumb abduction were also reasons for exclusion.

The median nerve conduction assessment was done by referring to the sensory latency, the motor

latency, and compound muscle action potential (CMAP) amplitude. The sensory latency was recorded from the third finger, and it was stimulated at a point which was 12 cm proximal to the recording electrode. The motor latency and CMAP amplitude were measured at the mid portion of the abductor pollicis brevis muscle and by the stimulation of the median nerve 8 cm proximal to the recording electrode.

The median versus radial first digit sensory latency difference and the median versus ulnar fourth digit sensory latency difference were measured by recording at points which were 8 cm away from the recording electrodes and by a stimulating electrode the same distance away from the recording electrode.

The distance between active and reference electrodes was 4 cm. A metal ground electrode was placed between the active and stimulating electrodes.

Before and after performing the provocative wrist flexion for five minutes, the median nerve distal sensory latencies (DSLs), median versus radial first digit, and median versus ulnar fourth digit sensory latency differences were recorded.

If the patients met at least one of the following criteria, they were excluded from the study: The median nerve sensory latency longer than 3.45 ms, the motor latency longer than 4.0 ms, the motor amplitude smaller than 4.25 mv, the sensory latency difference of the median versus ulnar higher than 0.5 ms (median longer than ulnar), or the sensory latency difference of median versus radial higher than 0.5 ms (median longer than radial) before the five-minute full wrist flexion. If they had normal routine electrophysiological studies, they were asked to perform provocative wrist flexion for five minutes, and all the electrodiagnostic studies were repeated. The patients were seated on an exam chair, and their hands were relaxed by putting a pillow on their laps.

All the tests were performed by the same physiatrist and with the four-channel Medelec Synergy electromyography system (Oxford Instruments Medical, Surrey, England).

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, Illinois, USA) version 17.0 program with a paired sampled t-test. Statistical significance was set at 0.05.

RESULTS

The baseline demographic and clinical characteristics of the study population are shown in Table 1.

The mean value of the median DSL observed before the provocation was 2.92±0.25 and 2.91±0.25 ms afterwards, and the median versus the ulnar fourth digit sensory latency difference recorded before provocation was 0.21±0.20 and 0.24±0.17 ms afterwards.

The median versus radial first digit sensory latency difference recorded before provocation was 0.06±0.23 and 0.18±0.25 ms subsequently.

There was no statistically significant difference between the before-provocation and after-provocation mean values of DSL at the median nerve and the measurements of the median versus ulnar fourth digit sensory latency differences ($p>0.05$).

The difference between the two measurements of the median versus radial first digit latency difference was statistically significant, but this increase was not more than 0.5 ms, which was the expected value.

Nerve conduction studies and difference tests results before and after full wrist flexion of the study population are shown in Table 2.

TABLE 1: Clinical characteristics of the study population.

Characteristics	Values
Age (years) (mean±SD) n=27	42.9±9.5
Gender (Female/Male) n=27	23/4
Positive Tinel's sign, n=41	65.9%
Positive Phalen's test, n=41	68.3%
Ratio of affected dominant extremity, n=41	41.4%
Duration of symptoms (months)(mean±SD)	22.36±20.27

SD: standard deviation

DISCUSSION

Carpal tunnel syndrome is the most common entrapment neuropathy and is one of the most frequent reasons for patients being referred for electrodiagnostic study in the clinical setting.[1,4] The population studies report a prevalence rate of 4%.[5] An injury to the median nerve within the carpal tunnel is due to mechanical compression and ischemic damage occurring chronically and intermittently. This initially leads to alterations in myelination and, in more severe cases, can later cause axonal loss.[2,6]

Symptoms of CTS, such as numbness, pain, and paresthesia in the median nerve area, are much more frequent than what is found in physical examination findings, although the symptoms are usually not restricted to the territory of the median nerve. The distribution of pain and paresthesia is known to be extremely variable.[2] Different clinical tests are helpful in the diagnosis of CTS, for example Tinel's sign, Phalen's test, and the carpal tunnel compression test.

Standard criteria for the clinical diagnosis of CTS have not yet been established. There is also no consensus on whether this syndrome is of a clinical or electrophysiological nature. Normal electrophysiological findings do not rule out CTS.[1]

Nerve conduction studies concerning CTS show a slowing of the nerve conduction in the affected segment and may or may not be accompanied by a reduction in the amplitude of sensory and motor potentials. Although very mild lesions with no detectable electrophysiological alterations can occur, it is generally accepted that the slowing of the nerve conduction in the median nerve indicates compression damage. Therefore, NCS is a highly specialized technique for the detection of CTS. However, some patients may still not be diagnosed despite its effectiveness.[2,5]

To obtain more information for the diagnosis of very mild CTS, various methods have been developed.[3,7-9] One of the methods that recently was considered is NCS following provocative tests such as wrist flexion. The reason for its efficacy related to the nerve conduction criteria is either due to the decrease in the blood supply of the median nerve or increase in carpal tunnel pressure.

Bronson et al. showed that wrist flexion produced a significant increase in the motor latency of the median nerve.[8] In addition, Emad et al. investigated the effect of wrist flexion on suspected cases of CTS, and it was shown that wrist flexion for five minutes resulted in a significant change in the sensory response.[7]

Hansson and Nilsson determined the time necessary to reach a 50% reduction in the amplitude of the median antidromic sensory nerve action potential during wrist flexion.[10] During the wrist flexion, sensory conduction in the median nerve became partially blocked in the patients included in this study.

These studies have shown that ischemia resulting from wrist flexion causes the blockage of the median nerve.[7,8,10] However, in our study, the electrodiagnostic tests were performed in the neutral wrist position, so prolongation was not observed. The increases in the DSL and latency difference test that indicated ischemia in our results were due to the fact that we performed our tests at the neutral wrist position instead of at wrist flexion.

Conversely, Wiederien et al. investigated the effect of the median nerve compression test (MNCT) on median nerve conduction across the carpal tunnel.[11] In their study, it was observed that the use of the MNCT did not produce any signifi-

TABLE 2: Nerve conduction studies and differences tests before and after full wrist flexion.

	Before wrist flexion	After wrist flexion	p
Median nerve DSL (mean±SD) (msc)	2.92±0.25	2.91±0.25	0.812
Median vs. radial first digit sensory latency difference (mean±SD) (msc)	0.06±0.23	0.18±0.25	0.027
Median vs. ulnar fourth digit sensory latency difference (mean±SD) msc	0.21±0.20	0.24±0.17	0.581

DSL: Distal sensory latency; SD: Standard deviation; MSC: Millisecond.

cant changes in the sensitivity or specificity of latencies for the diagnosis of CTS. Also, Dunnan et al. did not find any differences between the controls and patients with CTS in median nerve latency prolongation after five minutes of wrist flexion.[12] These four trials have small study populations, but our study population was relatively large. We found that wrist flexion did not lead to significant changes in either the latency differences or the nerve conduction velocity of the median nerve in suspected CTS. This was true before and after wrist flexion for the diagnosis of CTS.

Two possible reasons exist to explain why the median nerve conduction velocity and difference tests were not affected after wrist flexion. First, in very mild CTS, the intratunnel pressure can suddenly diminish while electrophysiological studies are performed in the neutral positioned wrist. Additionally, there was an insufficient amount of intratunnel pressure to result in an electrophysiological evidence. Similarly, Luchetti et al. showed that carpal tunnel pressure was higher when the wrist was in extension compared to flexion.[13]

You et al. investigated the relationships between the clinical symptom severity scales and nerve conduction measurements in CTS and found them to be significant.[14] This may explain the conflicting results concerning the provocative tests. We performed our study on patients who did not have wasting or atrophy of the thenar eminence or weakness of thumb abduction. Thus, our participants may be accepted as having had very mild CTS. Distinctive results may be seen on the difference tests after wrist flexion provocation on patients who have moderate or serious CTS symptoms and signs.

Rosecrance et al. evaluated the recovery of the median nerve sensory nerve action potentials following provocative wrist flexion combined with resisted finger flexion in the hands of patients with CTS.[15] The hands with CTS had significant reductions in the nerve potential amplitude and prolongations of the latency following the median nerve provocation. This shows that the wrist flexion provocation test caused ischemia and nerve conduction blockage of the median nerve. Finger flexion may cause variances in the electrodiagnostic results, including the prolongation of DSL or an increase in the latency difference. In our study, we performed wrist flexion without finger flexion. Therefore, our results may not vary significantly.

In addition, Rosecrance et al. observed that hands with mild to moderate CTS had the greatest reduction in nerve potential amplitude and the longest amplitude recovery periods following median nerve provocation.[15] This correlation may support the theory of the relationship between symptom severity and nerve conduction abnormality. Since the level of CTS in our patients was very mild, we observed no abnormalities in the nerve conduction studies and difference tests.

Electrodiagnosis is a powerful tool that provides additional information to the history and physical examination findings leading to a proper diagnosis of the suspected CTS. However, the use of wrist flexion as a method to prolong standard latencies can be not recommended. Therefore, to identify these patients, a set of standardized electrophysiological studies with reasonable specificity would be useful.

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