손목터널증후군 환자에서 당뇨병이 수술 후 전기생리학적 결과에 미치는 영향

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The Effect of Diabetes Mellitus on Postoperative Electrodiagnostic Outcomes of Carpal Tunnel Syndrome

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Objective: The aim of this study was to compare the electrodiagnostic outcomes of carpal tunnel release in patients with and without diabetes with carpal tunnel syndrome (CTS), and to evaluate the effect of diabetes mellitus (DM) on electrodiagnostic outcomes.

Method: We conducted a retrospective analysis of 67 patients with electro-diagnostic evidence of CTS. Patients were classified into two groups according to the presence of DM. Both groups were evaluated using nerve conduction studies preoperatively and 3 weeks and 3 months postoperatively.

Results: There were no statistical differences in any of the electrodiagnostic parameters between groups 3 weeks postoperatively. However, there were statistical differences in the amplitude and the latency of compound muscle action potential, and sensory nerve conduction velocity 3 months postoperatively.

Conclusion: Patients with DM did not show a significantly different outcome 3 weeks after surgery but showed a worse electrodiagnostic outcome 3 months after surgery than those without DM.

Key Words: carpal tunnel syndrome, diabetes mellitus, electrodiagnosis, postoperative

Introduction

Carpal tunnel syndrome (CTS) is the most common

disorder caused by entrapment of the median nerve and is characterized by combinations of signs and symptoms.¹ The treatment of CTS is categorized into conservative and surgical. Conservative treatments are offered to patients who have the intermittent symptoms of mild to moderate CTS. Surgical treatment is usually offered to patients who have the symptoms of moderate to severe CTS, such as constant pain and numbness, severe sensory disturbance, or thenar mus-

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cle weakness. The efficacy of surgical treatment of CTS is well established and has offered results superior to non-surgical treatment.^{2,3} Most patients have sustained functional improvement with low recurrence rates after surgery.^{4,5}

Epidemiological and electrophysiological data on risk factors for CTS report a significant association between diabetes mellitus (DM) and CTS.⁶⁻⁸ The prevalence of electrophysiologic abnormalities of typical CTS, with or without any symptoms or signs of CTS, ranged from 22% to 34% in DM.⁹⁻¹¹ Hyperglycemia results in microangiopathy and ischemia, ultimately causing demyelination and aberrant collagen metabolism which leads to fibrosis. Through these pathological mechanisms, DM is associated with a number of musculoskeletal conditions such as CTS, trigger finger and general joint stiffness. The incidence of peripheral nerve compression increases especially in patients with DM who have peripheral neuropathy. The report related to this observation demonstrated an incidence of 2% in the non-DM population, of 14% in patients with DM without neuropathy, and of 30% in patients with DM with neuropathy.¹² In a study in South Korea, 111 of 587 patients with DM had peripheral polyneuropathy, CTS, or both. Among the 111 patients, 47 had peripheral polyneuropathy (42.3%), 29 had CTS (26.1%) and 35 had both (31.5%).¹³ The coexistence of DM and CTS might thus impede the diagnosis of CTS.¹⁴

Various studies comparing patients with CTS with and without DM have been conducted. Patients with CTS who have DM exhibit a trend toward lesser symptom improvement and have worse postoperative functional outcomes than those without DM in both short-term and long-term follow ups.^{15,16}

Several studies have systemically assessed electrodiagnostic results after surgery between the two groups (patients with and without DM), and the results are controversial. Ozkul et al. compared electrodiagnostic results between the two groups at 1 month and 1 year after surgery, and found that patients with CTS with DM had worse electrodiagnostic outcomes.¹⁷ However,

Mondelli et al. conducted an electrodiagnostic evaluation 1 and 6 months after surgery, and reported that patients with DM had the same probability of positive surgical outcomes as patients without DM.¹⁸

In this study, we aimed to (1) compare the electrodiagnostic outcomes of carpal tunnel release in patients with and without DM with CTS after surgical treatment and (2) evaluate the effect of comorbidity of DM on postoperative outcomes.

Materials and Methods

1) Subjects

This study was approved by the Institutional Review Board. Records were analyzed retrospectively from the register of patients with CTS who were surgically treated for CTS in the OO Hospital over a period of 7 years (2008~2015). The diagnosis of CTS was made based on clinical symptoms and signs and was confirmed by electrodiagnostic studies. DM was diagnosed according to the criteria of the World Health Organization.¹⁹ Patients with prior surgery for CTS and underlying metabolic disorders other than DM, such as alcoholism, genetic disorders, gout, rheumatic arthritis or abnormal thyroid function related to peripheral neuropathy, were excluded. We also excluded patients who were diagnosed with diabetic peripheral polyneuropathy. The criteria for diabetic peripheral polyneuropathy were based on the electrodiagnostic results presented by the Diabetes Control and Complications Trial Research Group in 1995²⁰ and the diagnostic criteria of our clinic (Table 1).

We performed analyses on the data from 111 wrists

Table 1. Diagnostic Criteria of Peripheral Neuropathy

1. Sural sensory amplitude	≤ 5 μ V
2. Median sensory amplitude	≤ 10 μ V
3. Peroneal motor amplitude	< 1 mV
4. Peroneal motor velocity	Distal latency ≥ 6 ms or NCV < 40 m/s
5. Peroneal F latency	Absent or > 55 ms
6. Median & Ulnar F latency	Absent or > 35 ms
7. Tibial F latency	Absent or > 55 ms
8. H reflex	Absent or > 35 ms

of 67 consecutive patients (age 53.9 ± 10.2 years, range 42~77 years, 61 women and six men) with CTS, as confirmed by the American Association of Neuro-muscular and Electrodiagnostic Medicine (AANEM) criteria. Patients with CTS were classified into two groups according to the presence of DM. All patients were evaluated preoperatively, as well as 3 weeks and 3 months postoperatively using a nerve conduction study (NCS) measures.

2) Nerve conduction study

The NCS was conducted using Nicolet Viking IV® (Nicolet Biomedical, Madison, WI, USA). Skin temperature was maintained above 32°C. The amplitude and the latency of the compound muscle action potential (CMAP), the amplitude of the median sensory nerve action potential (SNAP), and distal sensory nerve conduction velocity (SCV) were assessed.

A median motor NCS was employed to record the initial latency from baseline to peak amplitude from the abductor pollicis brevis muscle center (active site) while stimulation was performed at the wrist, 7 cm from the recording site. Standard tests included the median sensory nerve conduction velocity from the third digit/wrist segments and median distal motor latency from the wrist to the thenar eminence. When standard tests were normal, further segmental tests were performed over a short distance of 7 cm or comparative median/ulnar motor nerve studies were performed. A median sensory nerve conduction study was employed to record the initial latency and baseline to peak amplitude from the third finger (active site), with antidromic stimulation conducted 14 cm (wrist) and 7 cm (palm) from the recording site.

The electrodiagnostic criteria of CTS were as follows: (a) median nerve distal sensory latency > 3.7 ms and a ratio of proximal and distal onset latency > 2.0 , or (b) distal motor latency over the thenar > 4.2 ms, or (c) a difference between the median and ulnar nerve distal sensory latencies ≥ 0.6 ms.²¹

The severity for CTS was classified into mild, moder-

ate, or severe according to the Stevens's classification.²² Mild CTS was defined as prolonged median sensory latencies with or without SNAP amplitudes below the lower limit of the normal range. Moderate CTS was defined as abnormal median sensory latencies and prolongation of median motor distal latencies. Severe CTS was defined as prolonged median motor and sensory distal latencies, and with either an absent SNAP or low-amplitude or absent thenar CMAP. Normative values used in our clinic are presented in Table 2.

The electrodiagnostic parameters were assessed preoperatively and 3 weeks and 3 months postoperatively in the CTS with DM and CTS without DM groups.

3) Statistical analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 22 for Windows (IBM, Inc., Armonk, NY, USA). The differences in demographic data were analyzed with independent t-tests for parametric variables (age, sex, height, weight, and BMI) and chi-squared tests for the nonparametric variable (CTS severity). Parametric variables were presented as mean $\pm$ standard deviation (SD) and CTS severity was presented as the ratio (%). Continuous variables between the two groups were analyzed using analysis of covariance (ANCOVA), with the factors that had showed significant differences in the independent t-tests as covariances. The preoperative parameters was included in the covariance when comparing the postoperative parameters. p-values $<$

Table 2. Normative Values Used for the Median Nerve Conduction Study

Nerve conduction study	
Median CMAP	Distal latency ≤ 4.2 ms Distal amplitude ≥ 5 mV
Median SNAP	Distal latency ≤ 3.7 ms (stimulation site: wrist) Distal latency ≤ 1.9 ms (stimulation site: palm) Amplitude ≥ 20 μ V

CMAP: compound muscle action potential, SNAP: sensory nerve action potential

0.05 were considered statistically significant.

Results

1) Baseline characteristics

The baseline characteristics of the study participants are shown in Table 3. A total of 67 patients (111 wrists) with a diagnosis of CTS from May 2008 to October 2015 were analyzed retrospectively. Patients were classified into two groups according to the presence

Table 3. Baseline Characteristics of the Participants

Variables	Non-DM (N = 41, 68 wrists)	DM (N = 26, 43 wrists)	p-value
Age	53.7 ± 9.8	54.3 ± 10.4	0.673
Female n (%)	37 (90.2%)	24 (92.3%)	0.955
Height	158.5 ± 7.9	157.9 ± 7.3	0.560
Weight	59.4 ± 6.9	63.1 ± 6.3	0.007*
Body Mass Index (BMI)	23.9 ± 3.1	24.8 ± 2.8	0.012*
CTS severity (mild/moderate/ severe) (%)	12.2/65.9/22.0	7.7/57.7/34.6	0.490
DM duration (years)	NA	7.1 ± 4.2	

Values are mean ± standard deviation

DM: diabetes mellitus

*p < 0.05

of DM. DM was diagnosed in 26 of these patients (43 wrists), while 41 patients (68 wrists) did not have DM. Age, sex, height, and the severity of CTS were not statistically different between the DM and the non-DM group ($p > 0.05$), but weight ($p = 0.007$) and body mass index (BMI) ($p = 0.012$) were different.

2) Nerve conduction study

The ANCOVA results for the electrodiagnostic parameters between of both groups are shown in Table 4. Because weight and BMI showed significant differences between the groups in independent t-tests, we included them as covariances in the ANCOVA. There were no statistical differences in any of the parameters preoperatively ($p > 0.05$) or 3 weeks postoperatively ($p > 0.05$). Statistical differences were, however, found in the amplitude and the latency of CMAP and SCV 3 months postoperatively ($p < 0.05$). There was no statistical difference in SNAP amplitude 3 months postoperatively ($p = 0.401$).

Discussion

Twenty-six patients with CTS with DM and 41

Table 4. Preoperative and 3 Weeks and 3 Months Postoperative Median Nerve Conduction Study Findings in the Non-DM and DM Group

	Preoperative	Postoperative 3 weeks	Postoperative 3 months
CMAP amplitude (mV)			
Non-DM	6.3 ± 3.3	5.7 ± 3.5	6.1 ± 3.2
DM	5.2 ± 3.2	0.513	0.034*
p-value	0.081	5.2 ± 1.2	4.5 ± 0.8
CMAP latency (ms)			
Non-DM	5.7 ± 1.8	5.2 ± 1.2	4.5 ± 0.8
DM	6.1 ± 1.9	5.4 ± 1.3	5.2 ± 1.1
p-value	0.284	0.392	0.042*
SNAP amplitude (μV)			
Non-DM	13.8 ± 11.6	19.3 ± 14.7	22.8 ± 12.6
DM	10.2 ± 9.6	16.3 ± 11.8	18.5 ± 12.5
p-value	0.244	0.868	0.401
SCV (m/s)			
Non-DM	23.4 ± 14.1	30.3 ± 15.4	39.1 ± 11.4
DM	17.9 ± 15.8	22.8 ± 17.3	25.3 ± 10.8
p-value	0.066	0.128	< 0.001*

Values are mean ± standard deviation

DM: diabetes mellitus, CMAP: compound muscle action potential, SNAP: sensory nerve action potential, SCV: distal sensory nerve conduction velocity

*p < 0.05: Analysis of covariance (ANCOVA)

without DM underwent carpal tunnel release, and we compared electrodiagnostic parameters between two groups at 3 weeks and 3 months after surgery. There were electrodiagnostic improvements in both the DM and non-DM group 3 weeks and 3 months after surgery. A comparison of improvement between the two groups did not show statistically significant differences at 3 weeks postoperatively, but we observed differences at 3 months postoperatively, with the group with CTS with DM showing poorer electrodiagnostic outcomes than the group with CTS without DM.

Ozkul et al. compared the conduction velocity of the median sensory nerve before and after surgery in 22 patients with CTS with DM and 25 patients without DM.¹⁷ The electrodiagnostic values were less favorable at both 1 month and 1 year after surgery in the DM group, which is consistent with our results, both only the chronic phase. In our study, we compared the two groups at 3 weeks and 3 months after surgery, because we wanted to evaluate the effect of DM in the acute-to-subacute period. Our results show no statistical differences in the improvement of electrodiagnostic findings at 3 weeks postoperatively, but we did observe significant differences at 3 months postoperatively. This discrepancy between our results and those of Ozkul et al. may stem from several factors such as the time of examination (3 weeks vs 1 month) and different inclusion criteria. For example, Ozkul et al. excluded participants who showed no response in a motor or sensory nerve conduction study.

Haupt et al. reported the long-term prognosis of 60 patients operated on for carpal tunnel syndrome, assessed in a prospective study with a median follow-up period of 5.5 years.¹⁵ Analyses of motor, sensory, and electrodiagnostic findings and assessments of pain were performed. Their results were generally favorable, with a varying degree of improvement in 86% of cases. They found a trend toward lesser pain relief in patients with DM with CTS compared to patients without DM with CTS, but no statistical differences in electrodiagnostic findings. Moreover, the postoperative follow-

up period of patients was not consistent (2 years to 11 years). In our study, differences between the two groups emerged at a relatively early period after surgery (3 months), compared to the study by Haupt et al. (5.5 years), and the differences are statistically significant.

Mondelli et al. compared the results of surgical decompression of CTS in 24 patients with CTS with DM type 1 or 2 and 72 patients with CTS without DM.¹⁸ All patients underwent surgical release of CTS via the mini-incision of palm technique. Clinical and electrodiagnostic (conduction velocity of the median motor nerve) evaluations and a self-administered Boston Questionnaire (BQ) for the assessment of severity of CTS symptoms and hand functional status were completed before and 1 and 6 months after surgery. The electrodiagnostic improvements after surgery were observed in the two groups at both 1 and 6 months after surgery, however, there were no statistically significant differences. These findings are in contrast to our results. In our study, the improvements in electrodiagnostic values between the two groups were similar at 3 weeks, but different at 3 months after surgery. There are several possible explanations for the discrepancy between the two studies, for example surgical technique (mini-incision at palm vs conventional release) and the participants' demographic data. Mondelli et al. selected 19 patients with type 1 and 5 patients with type 2 DM; however, in our study, all patients with DM were type 2, and there were no patients with type 1 DM. In the study by Mondelli et al., 24 patients with CTS with DM (mean age 66.7 y) and 72 patients with CTS without DM (mean age 66.2 y) were enrolled. In our study, the participant sample consisted of 67 patients (26 DM, mean age 54.3 y and 41 non-DM, mean age 53.7 y) who were younger than those of Mondelli et al.

A relationship between CTS and DM has been reported previously. The frequency of CTS is greater in DM than in non-DM groups.⁹ Factors such as repetitive activities or obesity could produce more vulnerable

focal injury in patients with DM than in normal subjects.¹⁰ Reduced axoplasmic flow and increased water content of the peripheral nerve in DM are presumably the causes of the injury to nerves from chronic compression at sites of common entrapment.²³ In patients with DM without neuropathy, there may be a partial demyelinating structural change in the nerves.²⁴ In our study, we excluded patients with diabetic peripheral polyneuropathy, because we want to evaluate the pure-diabetic effect on CTS. The electrodiagnostic findings of diabetic polyneuropathy could include impairment of the median motor and sensory conduction study findings. There is no electrodiagnostic criterion to distinguish patients with diabetic polyneuropathy from patients with clinical CTS.¹²

This study has some limitations. First, the number of patients studied is relatively small. Further studies should aim to increase the number of subjects to produce more reliable results. Second, it may be difficult to compare the results to those from long-term follow-up observations, because the results were analyzed after only 3 months postoperatively. Further studies are needed to evaluate later time periods. Third, the patients included in this study were not categorized according to CTS severity. Dividing the patients further by CTS severity could be very informative. Finally, we did not evaluate the possible influence of other factors, including physical examination results, patient mood, general health, and the effects of underlying diseases on therapeutic effectiveness, including their potential correlation with the outcomes.

Conclusion

In this study, patients with DM showed worse electrodiagnostic outcomes than patients without DM 3 months after surgery, suggesting that DM is a risk factor for poor outcomes of surgical decompression for CTS. When evaluating electrodiagnostic prognosis after surgery, the presence or absence of DM in CTS should thus be considered as an important factor.

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