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Research Article

Quantitative Sensory Evaluation of Carpal Tunnel Syndrome Using the Semmes-Weinstein Monofilament Test

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Abstract

The Semmes-Weinstein monofilament test (SWT) is useful for diagnosing carpal tunnel syndrome (CTS), but not generally preferred. A newly developed quantitative sensory evaluation method using SWT scoring was applied to 150 preoperative and 23 postoperative CTS hands. For SWT scoring, the median nerve area was divided into 17 segments. Each segment was scored from 0 to 3 points based on minimum pressure sensation, and the sum of each segment was scored using four score-totalling methods. Four different scoring methods were investigated and analysis was done to figure out the best clinical application. All four methods reflected CTS severity and correlated with each other. The method, in which scores distal to the metacarpophalangeal joints for each finger were summed, was simple to perform and clearly reflected not only CTS severity but also postoperative recovery. A newly developed quantitative sensory evaluation method based on SWT scoring seemed to be useful for evaluating both preoperative and postoperative CTS.

Keywords: Carpal Tunnel Syndrome; Semmes-Weinstein Monofilament Test; Sensory Evaluation

Introduction

Sensory evaluation, including pain, dysthesia, and hypesthesia, is very important for the diagnosis of CTS, but not quantitative for evaluating both the preoperative severity and the postoperative recovery. Nerve conduction study is well known as a quantitative evaluation, but sensory nerve action potentials are often undetected in severely affected patients. Therefore, a quantitative sensory evaluation method is necessary for severe CTS. SWT is a sensitive sensory evaluation method using 20 monofilaments that gradually increase in thickness to detect minimum pressure sensation. The monofilaments are marked with numbers that represent the logarithm of 10 times of the applied force in milligrams (1.65-6.65) [1-3] (Figure 1). The SWT method is useful for quantitative sensory evaluation of preoperative and postoperative CTS [4], but it is not generally used. Even though the SWT is quantified using the logarithm, it is complicated and difficult to understand. Here we describe a newly developed quantitative sensory evaluation method based on SWT scoring and its application for CTS.

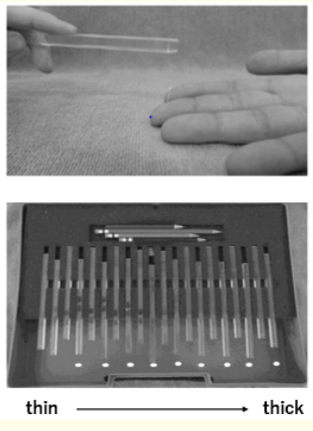

Figure 1: Semmes-Weinstein monofilament test; 20 monofilaments that gradually thicken are used to detect minimum pressure sensation, marked numbers represent the logarithm of 10 times the force in milligram. In this study, nine representative monofilaments (2.83-6.65) were picked up to simplify SWT.

Materials and Methods

Clinical research study was conducted on 150 hands of 114 CTS preoperative patients (85 women and 29 men, age range 34 - 89 years) and 23 hands of 22 postoperative patients (16 women and 6 men, age range 51 - 79 years). This study was not funded by any grant or company. Research protocols were approved by the Kameda-Daiichi Hospital human research ethics committee. For SWT scoring, the median nerve-dominated area was divided into 11 finger segments based on the distal interphalangeal/interphalangeal (DIP/IP), proximal interphalangeal (PIP), and metacarpophalangeal (MP) joints of the thumb through the ring finger and 6 palmar segments. In this study nine representative monofilaments (2.83-6.65) were picked up to simplify SWT, and monofilament probing was performed three times in each segment, while the heavier monofilaments, numbers 4.08-6.65, were applied once [5]. Each segment was colored based on a scale according to the monofilament number [6], and scored from 0 thru 3 points based on minimum pressure sensation. Green (2.83) indicated normal sensation and was scored 0 points, blue (3.61) indicated diminished light touch and was scored 1 point, purple (4.08-4.31) indicated diminished protective sensation and was scored 2 points, and red (4.56-6.65) loss of protective sensation and was scored 3 points [7] (Figure 2). To evaluate the validity of the SWT scoring, 150 hands with CTS were grouped into 3 types as definite (A), possible (B) and questionable (C), which was defined by the number of fingers advanced to severity compared with the ulnar area (Figure 3), quantitative sensory evaluation was performed using 4 score-totalling methods, as follows: 1) sum of scores distal to DIPs (0-12), 2) sum of scores distal to PIPs/MP (0-24), 3) sum of scores distal to MPs (0-33), and 4) sum of scores of fingers and palm (0-51) (Table 1, Figure 4). Four score-totalling methods were also performed in ulnar nerve dominated area of ring and little fingers, and the difference in scores between median and ulnar nerve areas was examined. The correlation of the 4 score-toatlling methods was examined by Spearman's correlation. Patients that had surgery were also evaluated at 1 and 3 months after surgery. Postoperative improvement was also statistically processed by Wilcoxon t-test with Bonferroni correction.

Results

The 150 preoperative hands were classified into 82 definite, 40 possible, 28 questionable CTS and 122 hands were diagnosed as CTS. The sensitivity of SWT was 81%. The difference in scores between median and ulnar nerve areas was consistent with CTS

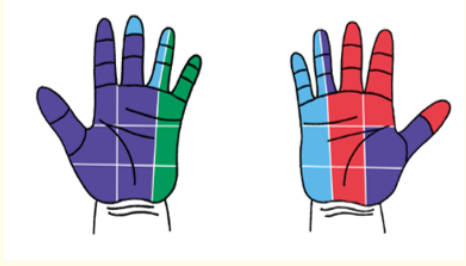

Figure 2: The median nerve-dominated area was divided into 17 segments, and each segment was scored. The red area was scored 3 points with 4.56-6.65, the purple area was scored 2 points with 4.08-4.31, the blue area was scored 1 point with 3.61, and the green area was scored 0 points with 2.83.

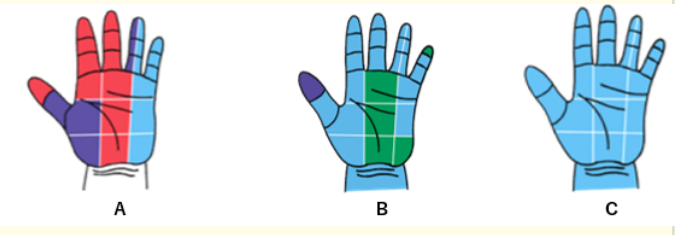

Figure 3: Severity of SWT scoring; 150 hands were grouped into 3 types, from definite to questionable, based on the number of abnormal digits. A (Definite); 3-4 digits, B (Possible); 1-2 digits, C (Questionable); 0 digits.

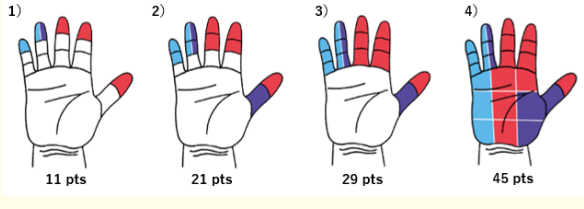

Figure 4: Quantitative sensory evaluation based on SWT scoring: In methods 1) thru 4), each hand scores 11 points, 21 points, 29 points, and 45 points, respectively.

Method	Score-totalling	Points
1)	Sum of scores distal to DIPs for each finger	0-12
2)	Sum of scores distal to PIPs for each finger	0-24
3)	Sum of scores distal to MPs for each finger	0-33
4)	Sum of scores for fingers and palm	0-51

Table 1: SWT scoring method.

severity in all 4 score-totalling methods, respectively, and the validity of the SWT scoring method was confirmed (Figure 5, Table 2). The results of methods 2) thru 4) were highly correlated with a correlation thru 0.94 to 0.97 (Table 3), and any method 2) thru 4) was suggested to be suitable for sensory evaluation in CTS. Postoperatively, the significant consecutive improvements of SWT score were shown in all methods 1) thru 4), with the 1%, 5% significance level at postoperative 1 and 3 months, respectively. The SWT scoring is considered the valuable parameter for reflecting and predicting postoperative improvement (Figure 6, Table 4).

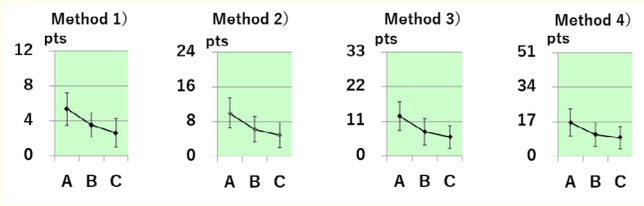

Figure 5: Difference in scores between Median and Ulnar nerve areas was consistently increased with CTS severity. A; 82hands, B; 40 hands, C; 28 hands.

	Definite	Possible	Questionable
Method 1)	5.4 ± 1.9	3.5 ± 1.4	2.6 ± 1.6
Method 2)	10.0 ± 3.5	6.2 ± 3.0	4.9 ± 2.9
Method 3)	12.6 ± 4.5	7.7 ± 4.2	6.0 ± 3.6
Method 4)	16.5 ± 6.7	10.7 ± 5.9	9.1 ± 5.4

Table 2: Difference in scores between median and ulnar nerve areas.

	Method 2)	Method 3)	Method 4)
Method 1)	0.93	0.92	0.87
	Method 2)	0.97	0.94
		Method 3)	0.96

Table 3: Correlation in 4 scoring methods. Methods 2) thru 4) were highly correlated; r≧0.94 (Spearman's correlation).

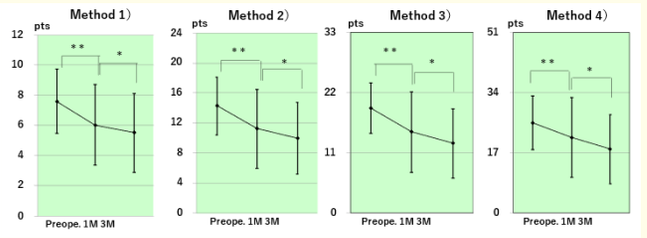

Figure 6: Postoperative consecutive improvement in SWT scores: Methods 1) thru 4) reflected significant recovery at 1 and 3 months after surgery, respectively ($p < 0.01, 0.05$).

	Preoperative	P.O. 1m	P.O.3m
Method 1)	7.6 ± 2.2	6.0 ± 2.7	5.5 ± 2.6
Method 2)	14.3 ± 3.9	11.3 ± 5.3	10.0 ± 4.8
Method 3)	19.1 ± 4.6	14.8 ± 7.4	12.7 ± 6.3
Method 4)	25.6 ± 7.6	21.3 ± 11.2	18.0 ± 9.8

Table 4: Postoperative improvement in SWT Scores.

Cases

The parameter for predicting postoperative improvement: The SWT score was compared with nerve conduction study using Distal motor latency(DML) and Distal sensory latency(DSL) to determine the most sensitive parameter. Case 1; The SWT score, DML and DSL showed marked improvement over time. Case 2; DML and DSL were preoperatively undetected and remained undetected at 3 months, while the SWT score showed improvement over time, clearly reflecting the postoperative recovery (Figure 7).

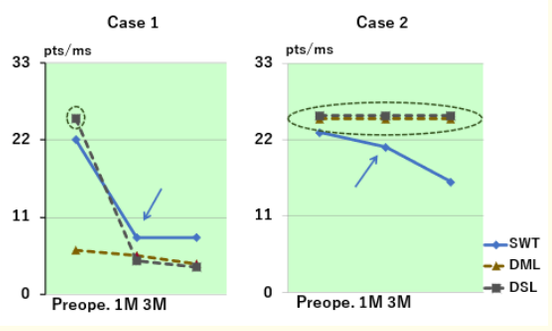

Figure 7: All parameters showed marked improvement in case 1, but in case2 with severe CTS, only SWT reflected recovery. The dotted circles indicates that the parameters were not detected.

Discussion

Nerve conduction studies are highly effective for diagnosing CTS quantitatively, but they are not sufficiently sensitive for the evaluation of mild CTS in the early stage. SWT is an examination based on the reaction of the Merkel Cell-neurite complex, which is a slowly adapting mechanoreceptive unit [8] and detects the threshold of a unit of the peripheral sensory nerve, and is very sensitive for the evaluation of entrapment neuropathy, including during postoperative recovery [9,10]. More systemic tests and more accurate documentations were required by using a grid worksheet [11], we modified von Prince's light touch and pressure test and designed the SWT scoring system. Our scoring methods reflected the CTS severity, and methods 2) thru 4) were shown to be highly correlated. Therefore, any of the methods, 2) thru 4), were useful for evaluating CTS. In postoperative recovery, scoring the broader area was assumed to reflect the recovery grade, while methods 2) thru 4) of the SWT scoring were also confirmed to be useful for the consecutive evaluation after surgery. But in method 2), the recovery scores at each interval were so small that they seemed to be inappropriate for clinical use. On the other hand, method 4) was more complicated to perform. Method 3) was simple to perform and clearly reflected even postoperative recovery and proved to be clinically appropriate. This method was also reported to have high inter- and intra- rater reliabilities and demonstrated the validity of the evaluation method for clinical application [12]. Although the patient's cooperation and concentration are required in SWT, it takes less than 15 minutes for skillful occupational therapists to perform our method. It is expected to be generally applicable.

Conclusion

A newly developed quantitative sensory evaluation method based on SWT scoring, in which scores distal to the metacarpophalangeal joints for each finger are summed, proved to be useful for evaluating both preoperative and postoperative CTS. Our approach will be capable of assessing CTS simply and accurately over time.

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Volume 5 Issue 11 November 2021