

Ring Finger Sensory Latency Difference in the Diagnosis and Treatment of Carpal Tunnel Syndrome

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Research Article

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Abstract

Objective: To explore the evaluation value of the sensitivity of the median/ulnar nerve sensory latency difference in the diagnosis of carpal tunnel syndrome and the evaluation value of severity.

Methods: 122 patients with CTS and 42 normal controls were collected from the department of Neurology in Renmin Hospital of Wuhan University from July 2019 to January 2021. Electrophysiological tests were performed on the CTS patients group and the control group. The distal latency of the sensory nerve action potential (SNAP) of the median nerve and the ulnar nerve of the two groups was recorded. According to electrophysiological results the patients were divided into three grades: mild, moderate and severe, the sensitivity of the nerve sensory action potential distal latency (SDL) to the diagnosis of CTS patients were analyzed, and the relationship with the severity of CTS was analyzed.

Results: There were significant differences between the median nerve sensory action potential distal latency (MSDL) of 179 affected hands and the control group; And median and ulnar sensory latency difference to ring finger (MUD) was significantly different from the control group; But ulnar nerve sensory action potential distal latency (USDL) was not significantly different from the control group ($P=0.182$). When the cutoff value of MSDL is 2.465ms, the sensitivity is 85.5% and the specificity is 90.4%; when the cutoff value of MUD is 0.38ms, the sensitivity is 100% and the specificity is 100%. In the mild, moderate, severe and control group, there was no significant difference in USDL between all the groups ($P=0.56$); between the control group and the mild group, moderate group, and severe group, and between the mild and moderate, significant differences were found in the MSDL and MUD. No significant difference between mild and severe ($P=0.66$), moderate and severe ($P=1.00$). MSDL and MUD are correlated with the severity of CTS. There is no correlation between USDL and CTS severity.

Conclusion: The ulnar nerve is not damaged in CTS; a smaller MSDL can reflect median nerve damage, which is beneficial to the early diagnosis of CTS; MUD is more sensitive than MSDL in diagnosing CTS; MUD is correlated with severity, which is beneficial to pain for patients who are more sensitive and cannot tolerate electrical stimulation, perhaps only measuring MUD can reflect the severity, relieve the patient's pain, and can be used to evaluate the therapeutic effect.

Background

Carpal tunnel syndrome (CTS) is the most common and widely studied nerve entrapment syndrome. It is caused by compression of the median nerve at the wrist as it passes through a space-limited osteofibrous canal. CTS is usually characterized by symptoms in the hand, in severe cases, it can involve forearms, upper arms, and even shoulders. Initially, it often exhibits intermittent nocturnal paresthesias and sensory disturbances that increase in frequency and occur during waking hours. Subsequently, loss of sensation develops along with weakness and thenar muscle atrophy later in the disease course.

(1) Diagnosis of CTS is based on clinical symptoms, physical examination findings, and electrodiagnostic (EDX) tests, primarily nerve conduction studies (NCS). (2) However, studies show that

routine EDX have limited sensitivity and specificity for the diagnosis of CTS (2-4). The American Association of Electrodiagnostic Medicine (AAEM) proposed that the median nerve sensory nerve conduction and the comparison of median and ulnar sensory conduction are more sensitive to the diagnosis of CTS(5).

Non-operative choices could be recommended in earlier grades. Some of these conservative options are oral medications like non-steroidal anti-inflammatory drugs (NSAIDs), resting wrist splint, physical agent modalities, and local injections including corticosteroid and platelet-rich plasma (PRP). Surgical release of the retinaculum has been approved for moderate to severe grades(6). Studies have found that when patients have mild symptoms, they often postpone medical treatment until the numbness worsens and thenar atrophy develops. while severe patients have slow recovery of symptoms even after surgery. (7).

The purpose of this study was to compare the sensitivity and specificity of different neuroelectrophysiological indexes in the diagnosis of CTS. And in the severity classification of CTS, the value of the MSDL and the MUD in the diagnosis and treatment of CTS. In order to diagnose and classify CTS early and conveniently, so as to guide the treatment of patients.

Materials And Methods

1.1 Participants

Patients group: According to the CTS diagnostic criteria listed by Pugdahl et al.(8), patients whose clinical manifestations meet the criteria are diagnosed as CTS. Exclusion criteria: ✎wrist trauma, deformity; ✎electrophysiological diagnosis showed polyneuropathy or radiculopathy; ✎electrophysiological diagnosis showed acute or chronic demyelinating disease. 179 hands were finally included in the study (Figure 1).

122 patients with CTS diagnosed in the department of Neurology of Renmin Hospital of Wuhan University from July 2019 to January 2021, with 222 affected wrists, were collected, and 179 wrists were finally included in the study due to incomplete nerve conduction test data and diseases that meet the exclusion criteria.

Control group: Recorded electrophysiological data of 52 healthy wrists, including 5 males with 5 wrists, and 37 females with 47 wrists, with an average age of 52.36 ± 13.21 years (17-77 years old).

1.2 Nerve conduction studies

All patients underwent nerve conduction studies in Keypoint Workstation (31A06, Alpine BioMedApS, Denmark), and kept the room temperature between 25°C and 28°C, so that the skin temperature of the hands was maintained between 32.0°C and 34.0°C. The severity of CTS was classified as mild, moderate, and severe, according to the NCS results (Table 1).

Table 1 Diagnostic criteria for the severity of CTS

Severity	Criteria
Mild	prolonged sensory latencies±SNAP amplitude below the lower limit of normal, with normal motor studies
Moderate	prolonged median motor distal latency in addition to abnormal sensory latencies like noted for mild CTS
Severe	any of the aforementioned NCS abnormalities with evidence of axonal loss defined by either: (1)an absent or low amplitude SNAP; (2) a low amplitude or absent thenar CMAP; or (3) a needle electromyogram revealing fibrillation potentials or neurogenic motor unit changes.

1.3 Statistical Analysis

SPSS25.0 was used for statistical analysis. The Kolmogorov–Smirnov test was used to evaluate whether the data was normally distributed. Parameters with a normal distribution were described as the mean ± standard deviation (SD), and those with a non-normal distribution were expressed as the median values (M) and interquartile range (Q). Continuous variables conform to normal distribution using analysis of variance, and non-normal distributions were compared using Kruskal-Wallis H test. Normally distributed data used Pearson correlation analysis, and non-normally distributed data used Spearman correlation analysis. The receiver operating characteristic curve (ROC curve) was used to determine the validity of the diagnostic value. $P < 0.05$ was considered to be significant.

Results

1. Clinical information

There were 122 CTS patients who met the inclusion criteria, including 22 males (18.0%) and 100 females (82.0%), with an average age of 54.43 ± 10.47 years (21-79 years). Among them, there were 100 cases (82.0%) with bilateral disease, 7 cases (5.7%) with one hand on the left and 15 cases (12.3%) with one hand on the right, with a total of 222 affected hands. 43 hands were excluded due to the lack of ring finger median or ulnar nerve latency. The 179 hands included in the study were divided into 3 groups according to the NCS results, of which 109 hands were mild, 66 hands were moderate, and 4 hands were severe. There are 17 patients with diabetes (27 hands), 4 patients with cerebrovascular accidents (6 hands), and 1 patient with rheumatoid disease (2 hands) (Table 2).

Table 2 List of clinical data of study patients

	Female	Man	Total
Average age (years)	54.69±10.71	53.27±9.42	54.43±10.47
Number of patients	1008(2.0%)	22(18.0%)	122
Total number of affected wrists	182(82.0%)	40(18.0%)	222
Number of wrists in the study	148(82.7%)	31(17.3%)	179
Number of cases on the right	11	4	15(12.3%)*
Number of cases on the left	7	0	7(5.7%)*
Number of bilateral cases	82	18	100(82.0%)*
With diabetes	23	4	27
With rheumatoid disease	2	0	2
Cerebrovascular accident	5	1	6

*As a percentage of the total number of cases

2. Comparison of NCS and ROC analysis between CTS group and control group

In 179 affected wrists, the MSDL and MUD in the CTS group were statistically significantly different from the MSDL in the control group and the MUD in the control group by Wilcoxon test($P < 0.01$). There was no significant difference in USDL between the two groups, $P = 0.182$ (Table 3).

Table 3 Comparison of the SDL between 179 wrists and the control group

Group	Median nerve	Ulnar nerve	MUD
Control group(n=52)	2.21(0.32)	2.06(0.28)	0.16(0.14)
CTS(n=179)	2.79(0.45)	2.02(0.27)	0.69(0.45)
W	1916	20198	1378
Z	-9.704	-1.335	-10.972
P	$P < 0.01$	$P = 0.182$	$P < 0.01$

*the data does not conform to the normal distribution, use the M(Q) to describe

The AUC of MSDL is 0.942, the best cutoff value for diagnosing CTS is 2.465ms, the sensitivity is 85.5%, and the specificity is 90.4%; when the AUC of MUD is 1, and the best cutoff value for diagnosing CTS is 0.38ms, the sensitivity is 100%, the specificity is 100% (Figure 2).

3. Comparison and correlation analysis of NCS between CTS mild, moderate, severe group and control group

Among the 179 affected wrists, according to the NCS results, they were divided into 109 mild, 66 moderate and 4 severe. According to Kruskal-Wallis H test, there was no significant difference in USDL between the mild, moderate, severe and control groups (P=0.56). There were significant differences in MSDL and MUD between the control and mild group, between the control and moderate group, between the control and severe group, and between mild and moderate, but no significant differences between mild and severe (P=0.66), moderate and severe (P=1.00) (Table 4, Figure 3).

Table 4 Ring finger sensory latency results in control group and CTS

Group	MSDL	USDL	MUD
Control group	2.21(0.32)	2.06(0.28)	0.16(0.14)
Mild CTS	2.63(0.360)	1.98(0.27)	0.60(0.31)
Moderate CTS	2.97(0.34)	2.055(0.32)	0.945(0.40)
Severe CTS	3.185 (0.49)	1.99(0.24)	1.195(0.26)
P	P<0.01*\$&!	P=0.056	P<0.01*\$&!

*P<0.01 for the control group compared with the mild group,\$P<0.01 for the control group compared with the moderate group,&P<0.01 for the control group compared with the severe group, ! P<0.01 in the mild group compared with the moderate group

V1 is the severity, 0=control, 1=mild, 2=moderate, 3=severe; V2 in Figure 3A is the MSDL; V4 in Figure 3B is MUD. The data distribution in Figure 3A and 3B shows that the higher the severity, the greater the MSDL and MUD.

By Spearman correlation analysis, there was a correlation between MSDL and CTS severity (r=0.745, P<0.01); there was a correlation between MUD and CTS severity (r=0.775, P<0.01). In contrast, there was no correlation between USDL and CTS severity (r=0.013, P=0.844) (Table 5).

Table 5 Correlation analysis between SDL and severity of CTS

	Severity	
	rs	P
MSDL	0.745	<0.01
MUD	0.755	<0.01
USDL	0.013	0.844

Discussions

In this study, it was found that the average age of CTS patients was 54.43 ± 10.47 years, the male to female ratio was about 1/4.5, and the incidence of females was much higher than that of males. The results of this study are similar to those of previous studies(1, 9, 10). The higher incidence of women may be caused by a combination of factors such as women taking on more housework in the family and changes in the hormone levels in women. Among the types of patients, bilateral incidence is the most (82%), and the number of patients on the right side is more than that on the left side, which is consistent with previous studies(9, 11, 12). The greater incidence on the right side than on the left may be due to the fact that the majority of people are right-handed and have more repetitive movements than left.

Some studies have shown that patients with CTS may have ulnar nerve damage(13, 14). A study found that when patients with CTS underwent carpal tunnel release, the pressure in Guyon's canal is reduced and the sensory conduction of the ulnar nerve improves(13). However, in several studies with larger numbers of patients, ulnar nerve conduction was found to be unaffected in patients with CTS(15–17). In our study, 179 affected wrists were included, a high number included, and there were no significant differences when USDL was compared with controls and when USDL was compared between different severities of CTS, these suggest that the ulnar nerve was not significantly damaged in patients with CTS.

We found that the MSDL and MUD of 179 wrists were significantly different from the control group, $P < 0.05$, and the AUC of MUD was 1, the AUC of MSDL was 0.942, both of which have high diagnostic accuracy. MUD AUC > MSDL AUC, which indicates that MUD is more accurate than MSDL in diagnosing CTS, which is consistent with the results of many studies reported so far(2, 3, 18, 19). And this difference may be due to individual differences, such as age, gender, weight, work, etc., resulting in different individual neurological status, such as older patients, due to the increase in age, neurological function decline, MSDL and USDL measurement The values are relatively prolonged. The simple prolongation of MSDL does not indicate that CTS can be diagnosed, but comparing with its own UN and calculating MUD can explain the problem better. Most of the previously reported MSDL cut-off values were between 2.7–3.8 ms, and more were around 3.7 ms, the sensitivity is 67%~90%, and the specificity is mostly greater than 90%(3, 11, 12, 18, 20–23). In our study, the sensitivity of MSDL to diagnose CTS was 85.5%, and the specificity was 90.4%, which was similar to the results of previous studies.

However, our study found that the optimal cut-off value of MSDL was 2.465 ms, which was smaller than the previously reported results. It may be that 97.7% of the total number of mild and moderate patients in this study were far more than severe, resulting in a lower MSDL value. Our study shows that when diagnosing CTS, compared with the current belief that the MSDL critical value is located at 4ms, it is possible to diagnose CTS at a smaller MSDL. We found that the best cutoff value of MUD to diagnose CTS was 0.38ms, the sensitivity was 100%, and the specificity was 100% (Fig. 1). Past studies have found that the diagnostic cut-off value is about 0.35ms ~ 0.81ms, the sensitivity is 85%~90%, and the specificity is 85%~96.7%(3, 11, 18, 20, 24, 25). We found that the optimal cutoff value of MUD for diagnosing CTS is 0.38ms, which is consistent with the results of previous studies. The difference is that

the sensitivity and specificity of this study are 100%, which are higher than previous studies. It may be due to that the control group was derived from the contralateral hand of the unilateral affected wrist, which has good comparability.

In the study, it was found that there were significant differences in MSDL between the control group and mild /moderate /severe, and between the mild and moderate CTS patients, and from the box plot (Fig. 3A), it can be found that the heavier the severity, the larger the MSDL, and from the correlation analysis, it is found that there is a positive correlation between MSDL and severity ($r_s = 0.745$, $r_s > 0$), indicating that the severity of CTS increases as the MSDL increases. In addition, there were significant difference in MUD between control group and mild/moderate/severe group, and between mild and moderate CTS patients, from the box plot (Fig. 3B), it is found that the heavier the severity, the larger the MUD, and from the correlation analysis, it is also found that there is a positive correlation, it is found that there is a positive correlation between MUD and severity. The correlation coefficient of MUD ($r_s = 0.755$) is larger than that of MSDL ($r_s = 0.745$), indicating that the correlation between MUD and NCS severity is better than that of MSDL, which is consistent with our previous finding that MUD AUC > MSDL AUC, MUD is more accurate than MSDL in diagnosing CTS.

In previous studies, as well as in this study, the CTS electrophysiological severity grading method published by Padua et al(26). The complete MN motor conduction and sensory conduction are needed to distinguish the severity. This study found that MUD is correlated with the severity of CTS. For patients who are more sensitive to pain and cannot tolerate electrical stimulation, perhaps only measuring MUD can reflect the severity and reduce the pain of the patient, which can further guide the patient to choose an appropriate treatment plan.

Conclusions

Our study found that the nerve conduction of the ulnar nerve in CTS patients did not change significantly, indicating that the ulnar nerve in CTS patients was not damaged.

97.7% of the patients included in the study were mild to moderate. It was found that a smaller MSDL could reflect median nerve damage and facilitate the early diagnosis of CTS. Compared with MSDL, MUD is more sensitive in diagnosing CTS, and MUD has a better correlation with severity. Perhaps only measuring MUD can reflect the severity, relieve the patient's suffering, and can be used to evaluate the therapeutic effect.

Limitation

Due to the lack of data on severe CTS wrists, the results of this study may not be applicable to all CTS, but this study included enough mild and moderate patients, and electrodiagnosis still has certain value. In this study, there were few severe patients, more patients with severe CTS would be needed to be included to determine the cut-off value for MUD to classify CTS in the future.

Abbreviations

CTS (carpal tunnel syndrome)

SNAP (sensory nerve action potential)

SDL (nerve sensory action potential distal latency)

MSDL (median nerve sensory action potential distal latency)

MUD (median and ulnar sensory latency difference to ring finger)

USDL (ulnar nerve sensory action potential distal latency)

NCS (nerve conduction studies)

EDX (electrodiagnostic)

ROC (the receiver operating characteristic curve)

AUC (area under the receiver operating characteristic curve)

Declarations

Ethics approval and consent to participate

The study was carried out according to the Declaration of Helsinki and the Guideline for Good Clinical Practice. This retrospective study was approved by the ethics committee of the Renmin hospital of Wuhan University, Wuhan, china. The informed consent was waived.

Consent for publication

Not applicable.

Availability of data and material

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

QW drafted the paper. HC, QW, HW, YJ, XZ was responsible for data collection. CW and ZL provided specialized expertise and critical appraisal of the article for submission.

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Figures

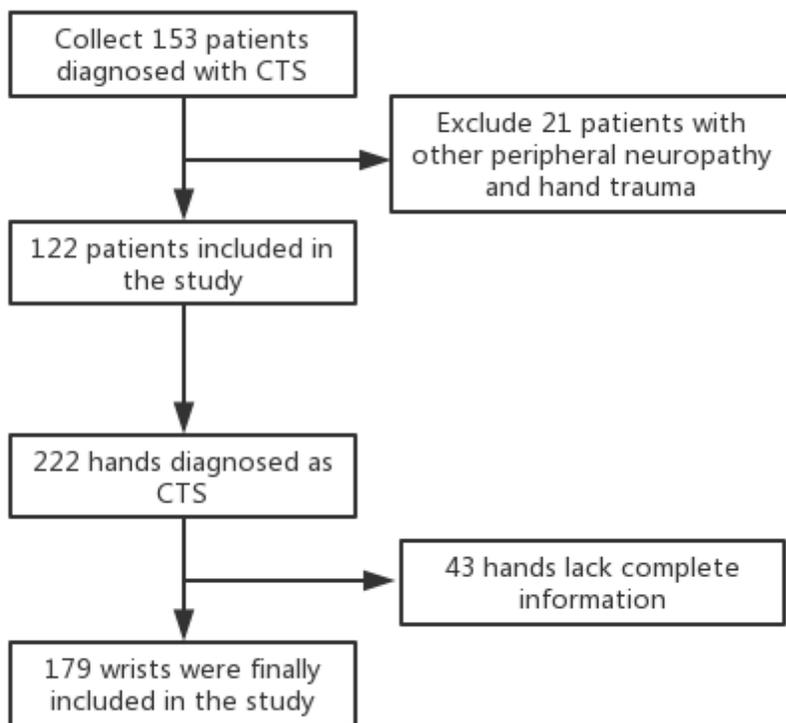
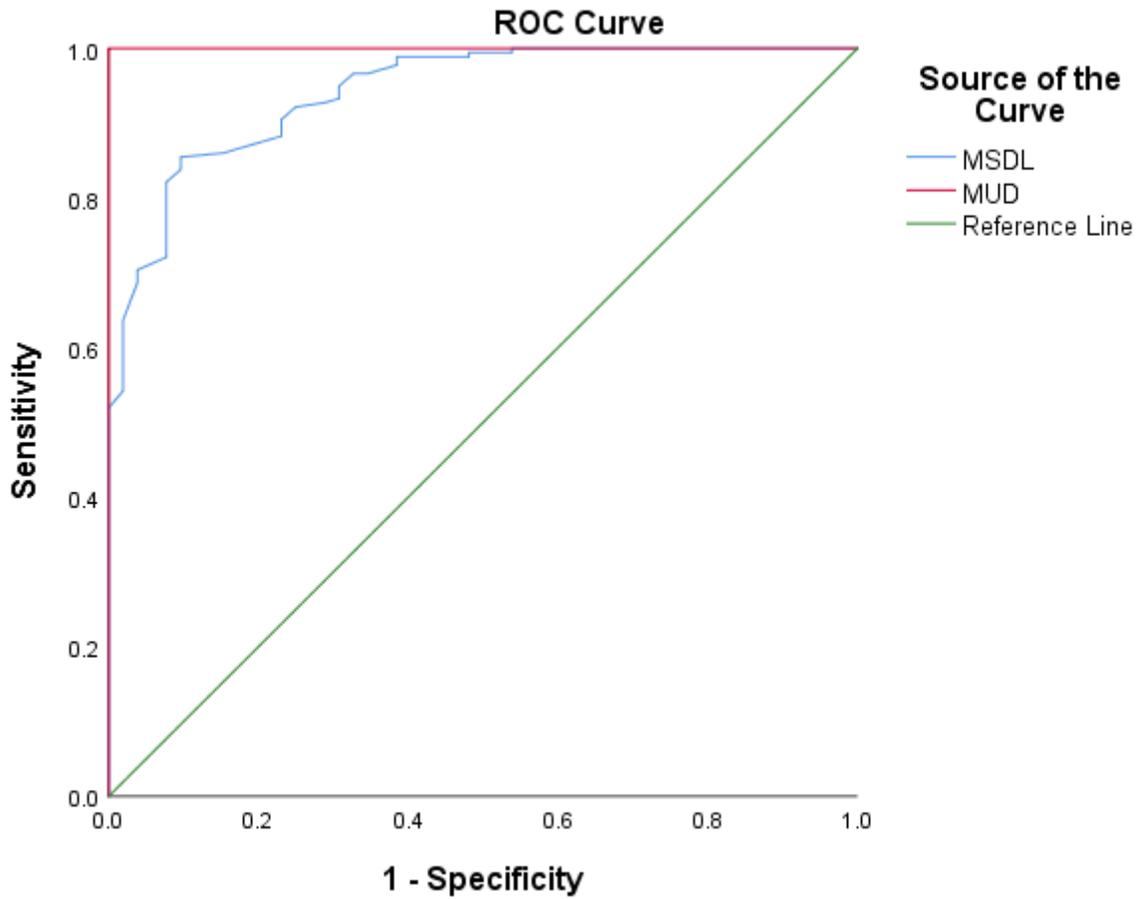


Figure 1

Flow chart of patient group inclusion



Diagonal segments are produced by ties.

Figure 2

ROC curve of MSDL and MUD of 179 wrists

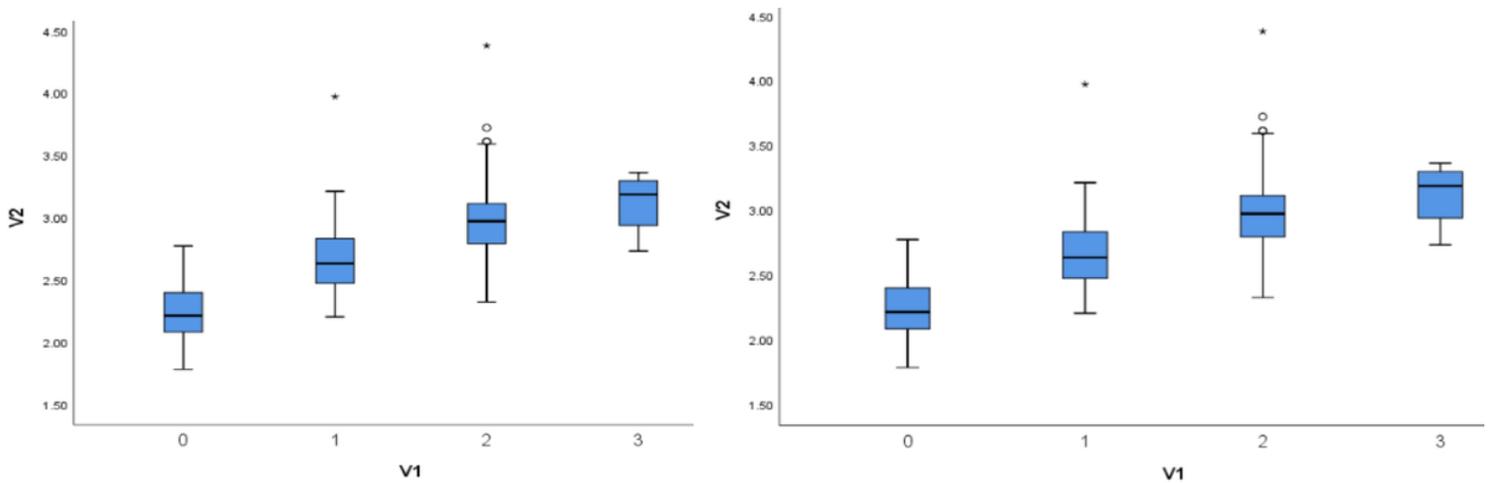


Figure 3

MSDL and MUD box plots for different degrees of CTS V1 is the severity, 0=control, 1=mild, 2=moderate, 3=severe; V2 in Figure 3A is the MSDL; V4 in Figure 3B is MUD. The data distribution in Figure 3A and 3B

shows that the higher the severity, the greater the MSDL and MUD.