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# An Analysis of Pinch Strength and EMG Parameters for CTS Group

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## ABSTRACT

It is known fact that the CTS patients have lower pinch strength than the normal people. And we can assume that the sensory nerve action potential(SNAP) and the nerve conduction velocity(NCV) of the CTS group are lower or slower than the normal subjects. This paper analysed the grip strength and performed EMG experiment for the group Norm, G1 and G2.

The results are as follows:

1) CTS patients have lower pinch strength than normal people.

2) There was no significant difference on SNAP between the CTS group and the normal group.

3) There was significant difference on NCV among Norm, G1, and G2 group. Especially, significant level was higher in the evening after the continuous use of wrist.

Keyword: CTS(carpal tunnel syndrome), NCV(nerve conduct velocity), SNAP(sensory nerve conduction potential)

## 1. INTRODUCTION

Recent trend is more focused on cumulative trauma disorders(CTDs) than occupational injuries such as back pain since there are great development in production and office automation (Taboun, 1990). These CTDs are caused

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by job risk factors such as the task repetition, inappropriate exertion(high levels of force), awkward posture, continuous stress, vibration, and cold. CTDs are chronic disorder which was caused by continuous exposure to the above job risk factors(Armstrong, 1986, Stock et al., 1991)

For example, there is transverse carpal ligaments in wrist where nine tendons and median nerve, which control hand movement, cross. When wrist is in awkward posture like over flexion or extension, it press tendon and carpal bones around median nerve. When this phenomenon is repeated for long period, it plugs micro blood circulation in median nerve which is known to cause carpal tunnel syndrome(CTS).

These CTDs are classified into tendon disorders, neurovascular disorders, and nerve disorders. CTS is a kind of nerve disorders(Turner and Buckle, 1987).

It is known that CTS patients have weaker grip and pinch strength (Sheik,1987, Dahalan et al., 1994). It is expected to recover strength after the end of task and the syndrome appears again after the use of hand(Kim, 1991).

Also, it is expected that CTS patients have lower electromyographic characteristics than normal people because CTS patient's median nerves are pressed by tendon and carpal bones when there is a problem in median nerve then it will have lower sensory nerve action potential(SNAP) and slower nerve conduction velocity(NCV).

We tried to find out the characteristic of the plnch shrergth of CTS patients by comparing between CTS patients and normal group. We measured pinch strength in the morning when subjects had plenty of rest and in the evening after repeatly using wrist.

Also, we tried to find the charteristics of CTS group's SNAP and NCV by EMG experiments.

## 2. THE SELECTION OF SUBJECTS AND THE METHOD OF EXPERIMENT

### 2.1 The Selection of Subjects

The subjects were 110 dentists who could have pain in the hand and wrist by repetitive motion. They were given physical discomfort test and the subjects who reported pain in the hand and wrist were given Phalen's test.

The subjects with pain were divided into two groups according to severity of pain. The subjects who reported pain in 30 seconds were put into G2 group and the subjects who reported pain in 60 seconds were put into G1 group. We randomly selected 4 people from G1, G2 and the normal group respectively.

### 2.2 The Method of Experiment

(1) Pinch Strength

Pinch strength can be different by working postures(Armstrong, 1987), repetition, gender, and age(Sheik, 1987).

The subjects from same group were

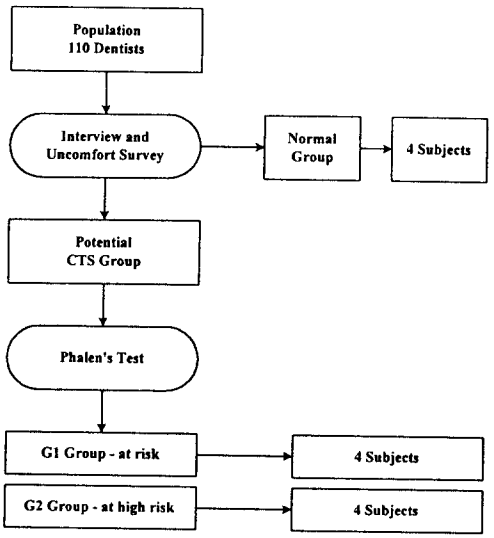


Fig. 1 shows the procedure of subject selection.

greatly affected by the task posture. So, we measured tip pinch strength in 90° and 135° elbow angle which were recommended by American Society of Hand Therapists. Tip pinch strength was measured at 10 A.M when subjects had plenty of rest and 6 P.M after the continuous use of wrist which could increase CTS.

Hydraulic Pinch Gauge(Jamar model : PC 5030 HPG) was used in this experiment which can measure up to 50lbs(22.5Kg).

(2) EMG Test

Surface electrodes were attached to three muscles which are Abductor pollicis brevis(P1), Flexor digitorum superficialis(P2), Palmaris longus(P3)

We followed John H. Warfel's method of selecting the location of electrode. We used Noraxon Myosoft 2000EMG and a bandfilter(16-500Hz) for this experiment. And experiments were performed during measuring pinch strength with EMG(setting 500Hz). The data were collected in the 586PC through A/D converter(100Hz).

## 3. THE RESULTS AND ANALYSIS OF THE EXPERIMENT

### 3.1 Pinch Strength

Table 1 is the result of ANOVA of pinch strength for three groups. Pinch strength were measured in the morning before work and in the evening after work.

The results of ANOVA were significant(P=0.01). This means that pinch strength decreased after the continuous use of wrist for all groups.

Table 2 is the results of grip strength difference among three groups for right and left hand. Grip strength was measured in the morning and evening in elbow angle of 90° and 135° respectively.

The results show significant difference between the use of wrist for all three groups. The results were more salient in G2 than G1, G1 than normal group, and right hand than left hand.

Table 3 is the results of Duncan's multiple range test for significant test.

For right hand, in 90° position, the results were Norm ≅ G1>G2 for both morning and evening.

But, for the 135° position, the results

Table 1. ANOVA of pinch strength for three groups

| Posture | Time | Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|---|---|
| 90° R | AM | Group | 2 | 315.39 | 157.69 | 7.47 | 0.0021 |
| | | Error | 33 | 696.83 | 21.11 | | |
| | | Total | 35 | 488.22 | | | |
| | PM | Group | 2 | 488.22 | 244.11 | 12.61 | 0.0001 |
| | | Error | 33 | 638.75 | 19.36 | | |
| | | Total | 35 | 1126.97 | | | |
| 90° L | AM | Group | 2 | 362.06 | 181.03 | 11.28 | 0.0002 |
| | | Error | 33 | 529.58 | 16.05 | | |
| | | Total | 35 | 891.64 | | | |
| | PM | Group | 2 | 247.72 | 123.86 | 7.22 | 0.0025 |
| | | Error | 33 | 566.17 | 17.16 | | |
| | | Total | 35 | 813.89 | | | |
| 135° R | AM | Group | 2 | 294.06 | 147.03 | 9.63 | 0.0021 |
| | | Error | 33 | 503.58 | 15.26 | | |
| | | Total | 35 | 797.64 | | | |
| | PM | Group | 2 | 491.56 | 244.11 | 16.3 | 0.0001 |
| | | Error | 33 | 497.42 | 19.36 | | |
| | | Total | 35 | 988.98 | | | |
| 135° L | AM | Group | 2 | 234.39 | 181.03 | 7.00 | 0.0002 |
| | | Error | 33 | 552.17 | 16.05 | | |
| | | Total | 35 | 786.56 | | | |
| | PM | Group | 2 | 207.72 | 123.86 | 7.58 | 0.0025 |
| | | Error | 33 | 452.17 | | | |
| | | Total | 35 | 659.89 | | | |

Table 2. Analysis of pinch strength difference for three groups

| group | posture | N | Min.dev | Max.dev | Mean | SD | t | p |
|---|---|---|---|---|---|---|---|---|
| Norm | 90° R | 12 | -1.00 | 5.00 | 2.00 | 1.91 | 3.633 | 0.0039 |
| | 90° L | 12 | -2.00 | 4.00 | 1.75 | 1.91 | 3.169 | 0.0089 |
| | 135° R | 12 | -1.00 | 4.00 | 1.42 | 1.38 | 3.559 | 0.0045 |
| | 135° L | 12 | -3.00 | 4.00 | 1.42 | 2.19 | 2.237 | 0.0469 |
| G1 | 90° R | 12 | 0.00 | 2.00 | 1.17 | 0.72 | 5.631 | 0.0002 |
| | 90° L | 12 | -1.00 | 5.00 | 1.25 | 1.91 | 2.264 | 0.0448 |
| | 135° R | 12 | -1.00 | 5.00 | 1.67 | 1.67 | 3.458 | 0.0054 |
| | 135° L | 12 | -2.00 | 6.00 | 1.92 | 2.27 | 2.919 | 0.0140 |
| G2 | 90° R | 12 | 2.00 | 7.00 | 3.58 | 1.62 | 7.656 | 0.0001 |
| | 90° L | 12 | -1.00 | 4.00 | 0.48 | 1.56 | 0.923 | 0.3760 |
| | 135° R | 12 | 0.00 | 7.00 | 3.42 | 2.19 | 5.396 | 0.0002 |
| | 135° L | 12 | -2.00 | 6.00 | 1.92 | 2.27 | 2.919 | 0.0140 |

Table 3. The results of Duncan's multiple range test

| Posture | Time | Group | Mean | MSE | POST HOC | |
|---|---|---|---|---|---|---|
| 90° R | AM | Norm | 27.42 | 21.11 | A | Norm ≅G1 >G2 |
| | | G1 | 23.75 | | A | |
| | | G2 | 20.17 | | B | |
| | PM | Norm | 25.42 | 19.35 | A | Norm ≅G1 >G2 |
| | | G1 | 22.58 | | A | |
| | | G2 | 16.58 | | B | |
| 90° L | AM | Norm | 23.92 | 16.05 | A | Norm >G1 >G2 |
| | | G1 | 20.50 | | B | |
| | | G2 | 16.17 | | C | |
| | PM | Norm | 22.17 | 17.16 | A | Norm ≅G1 >G2 |
| | | G1 | 19.25 | | A | |
| | | G2 | 15.75 | | B | |
| 135° R | AM | G1 | 25.67 | 15.26 | A | Norm >G1 >G2 |
| | | G2 | 22.25 | | B | |
| | | Norm | 18.67 | | C | |
| | PM | G1 | 24.25 | 15.07 | A | Norm >G1 >G2 |
| | | G2 | 20.58 | | B | |
| | | Norm | 15.25 | | C | |
| 135° L | AM | G1 | 21.50 | 16.73 | A | Norm ≅G1 >G2 |
| | | G2 | 18.42 | | A | |
| | | Norm | 15.25 | | B | |
| | PM | G1 | 20.08 | 13.70 | A | Norm >G1 ≅G2 |
| | | G2 | 16.50 | | B | |
| | | Norm | 14.25 | | B | |

were Norm>G1>G2. Above results show that wrist is more affected in 135° position than in 90° position.

Although, there was significant difference in morning and evening for Norm and G2, there was no difference between Norm and G1 in the morning. But there was significant difference in the evening after the continuous use of wrist.

### 3.2 EMG test

We can assume that the CTS group have lower SNAP and slower NCV because their median nerves are pressed by tendon and carpal bones.

The experiment was performed at the same time as measuring grip strength. The location of surface electrode was same in the morning and in the evening

Table 4. ANOVA of time difference for three groups

| Posture | Time | | Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|---|---|---|
| 90° R | AM | T1 | Group | 2 | 7210.33 | 3605.17 | 21.34 | 0.0001 |
| | | | Error | 21 | 3547.00 | 168.90 | | |
| | | | Total | 23 | 10757.00 | | | |
| | | T2 | Group | 2 | 5594.25 | 2797.12 | 23.88 | 0.0001 |
| | | | Error | 21 | 2460.25 | 117.15 | | |
| | | | Total | 23 | 8054.00 | | | |
| | PM | T1 | Group | 2 | 17120.33 | 8560.17 | 56.22 | 0.0001 |
| | | | Error | 21 | 3197.50 | 152.26 | | |
| | | | Total | 23 | 20317.83 | | | |
| | | T2 | Group | 2 | 9483.08 | 4902.04 | 49.40 | 0.0001 |
| | | | Error | 21 | 2083.75 | 99.23 | | |
| | | | Total | 23 | 11887.83 | | | |
| 90° L | AM | T1 | Group | 2 | 9483.25 | 4741.62 | 29.26 | 0.0001 |
| | | | Error | 21 | 3402.75 | 162.03 | | |
| | | | Total | 23 | 12886.00 | | | |
| | | T2 | Group | 2 | 7251.08 | 3625.54 | 31.35 | 0.0001 |
| | | | Error | 21 | 2428.75 | 115.65 | | |
| | | | Total | 23 | 9679.83 | | | |
| | PM | T1 | Group | 2 | 17104.00 | 8552.00 | 61.12 | 0.0001 |
| | | | Error | 21 | 2938.50 | 139.92 | | |
| | | | Total | 23 | 20042.50 | | | |
| | | T2 | Group | 2 | 11581.00 | 5790.00 | 23.87 | 0.0001 |
| | | | Error | 21 | 5093.50 | 242.54 | | |
| | | | Total | 23 | 16674.50 | | | |
| 135° R | AM | T1 | Group | 2 | 8792.58 | 4396.29 | 19.43 | 0.0001 |
| | | | Error | 21 | 4750.75 | 226.23 | | |
| | | | Total | 23 | 13543.33 | | | |
| | | T2 | Group | 2 | 6616.75 | 3308.37 | 27.81 | 0.0001 |
| | | | Error | 21 | 2497.87 | 118.94 | | |
| | | | Total | 23 | 9114.62 | | | |
| | PM | T1 | Group | 2 | 19285.58 | 9642.79 | 72.74 | 0.0001 |
| | | | Error | 21 | 2783.75 | 132.55 | | |
| | | | Total | 23 | 22069.33 | | | |
| | | T2 | Group | 2 | 11061.75 | 5530.87 | 49.83 | 0.0001 |
| | | | Error | 21 | 2330.75 | 110.98 | | |
| | | | Total | 23 | 13392.50 | | | |

| Posture | Time | | Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|---|---|---|
| 135° L | AM | T1 | Group | 2 | 10525.28 | 5262.79 | 31.64 | 0.0001 |
| | | | Error | 21 | 3493.37 | 166.35 | | |
| | | | Total | 23 | 14018.95 | | | |
| | | T2 | Group | 2 | 6946.75 | 3473.37 | 35.38 | 0.0001 |
| | | | Error | 21 | 2061.75 | 98.17 | | |
| | | | Total | 23 | 9008.50 | | | |
| | PM | T1 | Group | 2 | 18480.08 | 9240.04 | 70.53 | 0.0001 |
| | | | Error | 21 | 2751.25 | 131.01 | | |
| | | | Total | 23 | 21231.33 | | | |
| | | T2 | Group | 2 | 10544.08 | 5272.04 | 45.90 | 0.0001 |
| | | | Error | 21 | 2411.87 | 114.85 | | |
| | | | Total | 23 | 12955.95 | | | |

for prevention of measuring error.

But in the actual experiment, there was no significant difference in SNAP according to pinch strength among three groups. But there was significant difference in NCV according to different measuring points.

Table 5. Analysis of time difference between T1 and T2

| Group | Posture | Time | Min. dev | Max.dev | Mean | SD | T | P |
|---|---|---|---|---|---|---|---|---|
| Norm | 90° R | T1 | -20.00 | -2.00 | -9.00 | 6.09 | -4.177 | 0.0042 |
| | | T2 | -13.00 | -1.00 | -5.50 | 4.17 | -3.726 | 0.0074 |
| | 90° L | T1 | -15.00 | -3.00 | -8.37 | 4.07 | -5.822 | 0.0006 |
| | | T2 | -16.00 | 2.00 | -5.87 | 5.54 | -2.999 | 0.0200 |
| | 135° R | T1 | -22.00 | -3.00 | -9.87 | 6.38 | -4.378 | 0.0032 |
| | | T2 | -15.00 | -5.00 | -8.37 | 3.29 | -7.195 | 0.0002 |
| | 135° L | T1 | -21.00 | -1.00 | -11.25 | 6.79 | -4.681 | 0.0023 |
| | | T2 | -14.00 | -1.00 | -7.50 | 4.69 | -4.523 | 0.0027 |
| G1 | 90° R | T1 | -8.00 | -2.00 | -4.50 | 1.77 | -7.180 | 0.0002 |
| | | T2 | -13.00 | -4.00 | -7.13 | 2.90 | -6.949 | 0.0002 |
| | 90° L | T1 | -8.00 | -3.00 | -5.75 | 1.98 | -8.205 | 0.0001 |
| | | T2 | -17.00 | 45.00 | -0.50 | 19.08 | -0.074 | 0.9430 |
| | 135° R | T1 | -7.00 | 3.00 | -2.00 | 3.02 | -1.871 | 0.1036 |
| | | T2 | -14.00 | 1.00 | -4.75 | 4.71 | -2.851 | 0.0247 |
| | 135° L | T1 | -13.00 | 0.00 | -6.37 | 3.89 | -4.636 | 0.0024 |
| | | T2 | -14.00 | 3.00 | -5.50 | 5.80 | -2.679 | 0.0316 |
| G2 | 90° R | T1 | -51.00 | -4.00 | -30.75 | 14.71 | -5.911 | 0.0006 |
| | | T2 | -37.00 | 4.00 | -16.87 | 12.39 | -3.852 | 0.0063 |
| | 90° L | T1 | -38.00 | -7.00 | -22.62 | 11.97 | -5.344 | 0.0011 |
| | | T2 | -27.00 | 1.00 | -13.62 | 9.68 | -3.981 | 0.0053 |
| | 135° R | T1 | -56.00 | -9.00 | -29.62 | 16.08 | -5.211 | 0.0012 |
| | | T2 | -34.00 | -6.00 | -18.00 | 9.63 | -5.283 | 0.0011 |
| | 135° L | T1 | -56.00 | 3.00 | -13.78 | 12.97 | -10.40 | 0.0001 |
| | | T2 | -37.00 | 45.00 | -9.08 | 10.22 | -8.70 | 0.0001 |

In Table 4, T1 and T2 is the time difference between electrode location P1 and P2, and P2 and P3 respectively.

It is unclear on why there is no significant difference for SNAP, further research is needed on this matter.

Table 5 is the analysis of time difference between T1 and T2 which were measured in the morning and in the evening for all groups. The results show that the NCV decreases for all groups. Furthermore, there is greater decrease in G2. This phenomenon is caused by pressed wrist's transverse carpal ligament which was resulted from repetitive wrist movement.

## 4. CONCLUSIONS

Hypothesis was that CTS group would have weaker pinch strength, lower SNAP, and slower NCV which were resulted from pressing median nerve by wrist tendon and carpal bones. Four subjects were selected for each of three groups, which were Norm, G1, and G2. So, total of twelve subjects participated in this experiment using pinchguage and EMG.

The followings are results from this experiment:

1) CTS group has lower pinch strength than the normal people. Especially, which was measured in the evening was lower than that of strength which was measured in the morning. The pinch strength decreases as CTS increases.

2) Lower SNAP for CTS group than the normal people was expected but in the experiment, there was no significant difference.

More research should be done because it is not clear why we got this result. The result could reflect real insignificance or error in experimental design.

3) There was significant different NCV among Norm, G1, and G2. Especially, significance level was higher in the evening after work.

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