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# Comparison of Current Perception Threshold between Each Side in Unilateral Complex Regional Pain Syndrome Patients does not Measure the Patient's Pain

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## ABSTRACT

The current perception threshold (CPT) test has been developed as one of the neuroselective sensory nerve conduction threshold tests. The score of the CPT of the affected side subtracted from the score of the CPT of the unaffected side in complex regional pain syndrome (CRPS) is expected to show pain objectively. The purpose of this study is to examine first whether the CPT of the affected side is generally lower than that of the unaffected side, and second, whether the greater score shows the more intense pain. The CPT of each side in 25 patients with unilateral CRPS type I was measured and compared. For the 2000 Hz stimulus, the CPT of the affected side was 2677 ± 262 $\mu$Amp (mean ± standard error) and the CPT of the unaffected side was 2194 ± 247 $\mu$Amp ($p = 0.0149$). For the 250 Hz stimulus, the CPT was 876 ± 117 $\mu$Amp and 721 ± 73 $\mu$Amp respectively ($p > 0.05$). For the 5 Hz stimulus, the CPT was 730 ± 105 $\mu$Amp and 448 ± 56 $\mu$Amp respectively ($p = 0.0018$). In 2000 Hz, 250 Hz, and 5 Hz stimuli, the CPT of the affected side was higher than that of the unaffected side. This shows that generally the affected side is less sensitive than the unaffected side in terms of current perception. The score of the CPT of the affected side subtracted from the score of the CPT of the unaffected side in CRPS does not measure the patient's pain.

***Key words:*** *Current perception threshold, Neurometer, Neuroselective sensory nerve conduction threshold, Reflex sympathetic dystrophy*

Complex regional pain syndrome (CRPS) is an intractable syndrome. If there is no associated major nerve injury it is known as CRPS type I, formerly known as reflex sympathetic dystrophy. If there is associated injury of a major nerve branch it is labeled CRPS type II, formerly known as causalgia. CRPS is a syndrome characterized by physical findings such as pain (burning pain, allodynia, hyperpathia, etc.), sensory disorder (hyposensitive or hypersensitive), swelling, contracture, sweating disorder (hyper-sweating or hypo-sweating), and color change. The syndrome occurs following an inciting event such as blunt trauma, fracture, myocardial infarction, hemiplegia, medical practice (operation, drip infusion, injection, collection of blood, catheterization, percutaneous examination, etc.), or following no inciting event. The affected region is often different from or beyond the injured region. The severity of symptoms is disproportionate to the degree of the inciting injury. The affected region is inconsistent with a peripheral nerve or spinal root pattern. Symptoms often spread in many directions.

It is difficult to evaluate pain. Patients' subjectivity alone is an individualized potential index of pain. While the visual analog scale (VAS) is often used to evaluate pain, the scale provides a purely subjective report. Therefore, it is not reliable to compare pain among subjects using the VAS.

A neuroselective sensory nerve conduction threshold test has been developed[4]. It enables comparison among subjects' perceptions. The current perception threshold (CPT) test, one of the neuroselective sensory nerve conduction threshold tests, is the most frequently used test. Studies among subjects with diabetes mellitus neuropathy[8] and carpal tunnel syndrome[3] find that the CPT is useful in diagnosing and assessing the pain level. The score of the CPT of the affected side subtracted from the score of the CPT of the unaffected side in CRPS may express pain as an objective number and enable comparisons of pain

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among many subjects. We hypothesize that the CPT of the affected side is generally lower than that of the unaffected side and the greater score shows the more intense pain. Previously, the CPT of CRPS subjects was measured, but comparison between each side was not made. In this study, we measured the CPT of each side in CRPS subjects and compared the measurements of the affected side with those of the contralateral, homologous region.

## MATERIALS AND METHODS

### *Patients*

Twenty-five subjects with unilateral CRPS type I had CPT testing completed mainly before treatment or sometimes immediately after the beginning of treatment. After examination, contrast bath and irradiation near the stellate ganglion with linear polarized near-infrared light were performed on the affected side. Some subjects had already taken medicine such as Neurotropin[10] at their first visit. Subjects did not take any pain medications within 17 hours before the examination. All subjects met the four cardinal signs and symptoms of CRPS as defined by Lankford, which are pain, swelling, stiffness and discoloration[5]. The study population included 16 women and 9 men (Table 1). The right side was involved in 11 subjects and the left side was involved in 14 subjects. The average age of the subjects was 47 years (range 25 to 75 years). The onset of CRPS to the testing time ranged from 10 days to 6 years with the average being 10 months. The upper limb was involved in 22 subjects and the lower limb in 3 subjects. The testing was completed at the site of the most painful region of the affected limb and at the contralateral, homologous region. The test was carried out at the thumb in 6 subjects, the index finger in 4 subjects, the middle finger in 5 subjects, the little finger in 1 subject, the dorsum of the hand in 1 subject, the wrist joint in 3 subjects, the forearm in 1 subject, the upper arm in 1 subject, the hallux in 1 subject, the third toe in 1 subject, the dorsum of the foot in 1 subject.

### *Statistics*

Differences between CPT on each side were statistically analyzed using the Wilcoxon signed rank test. A p value of less than 0.05 was considered significant.

### *Neurometer*

All measurements were performed in a quiet room with the subject comfortably seated. The methods were similar to those described previously[4,6,7,9,11]. The CPT was measured with a Neurometer (Neurotron Inc, Baltimore, MD) at 2000 Hz, 250 Hz, and 5 Hz. These stimulus frequencies at threshold have been reported to stimulate primarily large myelinated, small myelinated, and small unmyelinated fibers, respectively[4]. Stimulus current intensities ranged from 0 to 9990 $\mu$Amp. The CPT test uses a constant-current output, as opposed to a constant-voltage output. The constant-current output automatically compensated for changes in skin resistance and gave a standardized stimulus independent of different skin thickness, degree of skin dryness, perspiration, swelling, or drying of the electrode paste.

### *Procedure*

The following is a brief description of the procedure. A pair of 1 cm diameter gold electrodes, separated by a 1.7 cm Mylar spreader, was coated with a standard electrode paste and then taped to the test site. The CPT test began with the "Intensity Alignment Mode". The current was slowly increased manually from zero until the subject reported detecting a sensation around the site of the electrodes. The intensity was gradually decreased by manual control until the sensation was no longer detected. Then, the intensity was decreased in ten CPT value increments. One CPT value corresponded to 10 $\mu$Amp.

Next, an "Automated Forced Choice CPT Determination" was made to determine the actual CPT values automatically. The subject had a series of forced choice tests which consisted of randomly generated pairs of real and false (non-current) stimuli presented as a "Test A" and a "Test B" separated by a "Rest" period. A remote subject box had buttons paired with indicator lights labeled "Test Cycle", "Test A", "Rest/None", and "Test B". For each test period, a different audible tone was emitted and the corresponding button light was illuminated. The subject was instructed

**Table 1.** Clinical summary in 25 patients with unilateral complex regional pain syndrome

| | | |
|---|---|---|
| Sex | female: 16 | male: 9 |
| Side | right: 11 | left: 14 |
| Age | 25–70 (average 47) | |
| Duration of illness | 10 days-6 years (average 10 months) | |
| Site | upper limb: 22 | lower limb: 3 |
| Site of measurement | thumb: 6, index finger: 4, middle finger: 5, little finger: 1, dorsum of hand: 1, wrist joint: 3, forearm: 1, upper arm: 1, hallux: 1, third toe: 1, dorsum of foot: 1 | |

to indicate, either orally or by pressing the corresponding button, when the subject detected stimulation at the site of the electrodes, during "Test A" or "Test B". If no stimulus was detected or if the subject was unable to discern any difference between the test cycles, the subject was instructed to press the "Rest/None" button or speak verbally. Based on the subject's response, the device automatically adjusted the output level of the stimulus and randomly generated a new testing order for the next pair of tests in the series. Randomly placed double blind tests were present to assist in monitoring subject responses for accuracy and consistency. When a sufficient value of consistent responses was detected, the final CPT value was displayed on the device screen. This testing sequence was repeated for each of the three frequencies (2000 Hz, 250 Hz, 5 Hz) of stimulus before moving on to the contralateral, homologous site.

## RESULTS

For the 2000 Hz stimulus, the CPT of the affected side was 2677 ± 262 $\mu$Amp (mean ± standard error) and the CPT of the unaffected side was 2194 ± 247 $\mu$Amp ($p = 0.0149$). For the 250 Hz stimulus, the CPT was 876 ± 117 $\mu$Amp and 721 ± 73 $\mu$Amp respectively ($p > 0.05$), and for the 5 Hz stimulus, the CPT was 730 ± 105 $\mu$Amp and 448 ± 56 $\mu$Amp respectively ($p = 0.0018$). In all stimuli, the CPT of the affected side was higher than that of the unaffected side. Moreover, there were more subjects whose CPT of the affected side was higher than that of unaffected side. There were few subjects whose CPT of the affected side was lower than that of the unaffected side. The value of the CPT of the affected side subtracted from the CPT of the unaffected side had no relation to the duration of the subjects' illness (Fig. 1).

## DISCUSSION

Comparison between the CPT of each side is not valuable in metabolic diseases such as diabetes mellitus, because these diseases generally affect each side. Because of a subclinical abnormality, comparison between each side in carpal tunnel syndrome is not so valuable. However, CPT comparison between each side is valuable in CRPS, especially in the early stage, because CRPS usually affects only one side in that stage.

The neuroselective sensory nerve conduction threshold test in CRPS subjects was employed in a few studies. Raj et al[7] measured the CPT and pain tolerance threshold (PTT), the maximum

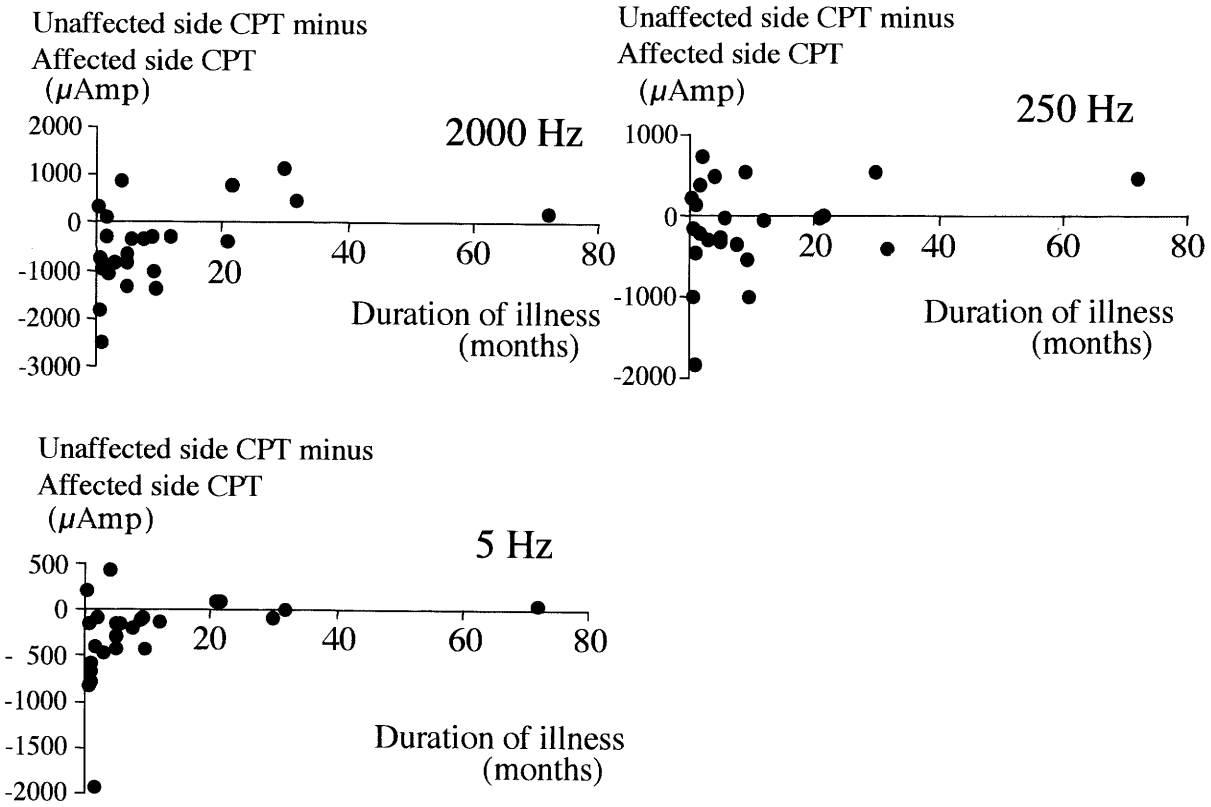


**Fig. 1.** Difference of current perception threshold (CPT) in each side. A vertical line shows the score of the CPT of the affected side subtracted from the score of CPT of the unaffected side. The affected side is the most painful region and the unaffected side is the contralateral, homologous region. A minus value means that the CPT of the affected side is greater than the CPT of the unaffected side. This demonstrates that the affected side is less sensitive than the unaffected side.

amount of current tolerated by subjects on the affected side, and compared the values of the affected side with the values of healthy normal people. Raj et al[7] reported that an abnormal PTT was detected with a higher sensitivity than an abnormal CPT. Both sides were not compared. Dinh et al[1] reported that the pain perception threshold (PPT) to the 5 Hz stimulus is at least three times that of the CPT at the same site in healthy individuals, and that 5 of the 9 subjects had PPT/CPT ratios less than 3.00 at the 5 Hz stimulus. PPT is a minimum current intensity that produces pain. Raj et al[7] and Dinh et al[1] did not compare the values of each side. Fingers are usually the most painful regions in CRPS in the upper limb. However, the palm or wrist may be the most painful region. When we make a CPT comparison between the upper limbs or a CPT comparison between the upper limbs and the lower limbs, the comparison among the CPT of different regions makes little sense. If the CPT is measured at a fixed region for comparison, the measured regions are often different from the area where CRPS patients show their strongest symptoms. Even if measurement is made at the region of the strongest symptom, comparison between each side enables comparison of the CPT among many subjects. Diagnostic criteria of CRPS are not composed of comparisons between the affected side of a CRPS patient and a healthy person, but are composed of comparisons between each side of the CRPS subject. The unaffected side of unilateral CRPS subjects may also have disorders. For example, hyperhidrosis and hyperalgesia are not defined by a comparison between the value of the affected side of a CRPS subject and the average value in healthy subjects. In the diagnostic criteria of CRPS, they are defined by a comparison between the value of the affected side and the value of the non-affected side. Although comparison between the CPT of the affected side and the CPT of healthy subjects is important, it is more important to make a comparison between the CPT of the affected side and the CPT of the non-affected side in CRPS subjects.

Yamashita et al[12] measured the CPT values in 48 lumbar disc herniation subjects who had pain due to the compression of one lumbar nerve root. The CPT values on the affected legs were significantly higher than those on the contralateral unaffected legs at all frequencies ($p < 0.01$). In subjects with hypoesthesia ($n = 24$), the CPT values on the affected legs were higher than those on the contralateral unaffected legs (2000 Hz and 250 Hz: $p < 0.001$, 5 Hz: $p < 0.01$) (Yamashita reported unpublished statistical results). In subjects without hypoesthesia ($n = 24$), the CPT values on the affected legs were higher than those on the contralateral unaffected legs (2000 Hz: $p < 0.001$, 250 Hz and 5 Hz: $p > 0.05$) (Yamashita reported unpublished statistical results). Yamashita et al[12] reported that the CPT values on the affected legs in patients with severe pain (VAS $\geq 5$, $n = 28$) were higher than those in subjects with less pain (VAS $< 5$, $n = 20$) (2000 Hz and 250 Hz: $p > 0.05$, 5 Hz: $p < 0.05$). The CPT of the more painful side was higher than that of the less painful side.

At first, we presumed that pain was able to be measured with the CPT test. Specifically, we presumed that the CPT of the affected side was lower than that of the unaffected side in unilateral CRPS patient. Our results agreed with the results of Yamashita et al[12]. in that the CPT of the affected side was higher than that of the unaffected side. Though statistically significant differences do not necessarily exist at all frequencies, the fact is acceptable as a whole.

Hypoesthesia is present at the painful region in some lumbar disc herniation subjects. However, hypoesthesia is not present in others as reported by Yamashita et al[12]. Similarly, hypoesthesia is present at the painful region in some CRPS subjects, while hyperesthesia is present at the painful region in other CRPS subjects. When the CPT of the affected side is higher than that of the unaffected side, we think it indicates that the affected side is less sensitive to electric stimulation than the unaffected side. We consider that the CPT measured with an electric stimulus is different from pain.

If we investigate relationships between CPT and hyperesthesia, hypoesthesia, allodynia, spontaneous pain, and VAS, a huge amount of data must be managed. For simplicity in this paper, we compared only the CPT of each side.

Subjects did not take any pain medications within 17 hours before the examination. Moreover, as described above, the CPT of each side was compared in this study. Therefore, we believe that treatment had little influence on the results.

The contrary view that comparison between the CPT of the affected side of CRPS subjects and the CPT of healthy subjects is more valuable than a comparison between the CPT of each side in the same patient simply mistakes the means for the end. The PPT or PTT between each side may be different from our results. In comparing the affected side with the unaffected side in CRPS patients, the ratio among three frequencies in CPT, PPT, or PTT may be different from our results.

In conclusion, we measured CPT in each side of 25 unilateral CRPS type I subjects and compared the CPT of the affected side with the CPT of the contralateral, homologous unaffected region. In 2000 Hz, 250 Hz, and 5 Hz stimuli, the CPT of the affected side was higher than that of the unaffected side. We conclude that the affected side is generally less sensitive than the unaffected side in terms of current perception. The score of the CPT of the affected side subtracted from the score of

the CPT of the unaffected side in CRPS is not a measure of the patient's pain.

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