CLINICAL ARTICLE

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Evaluation of Thermography in the Diagnosis of Carpal Tunnel Syndrome : Comparative Study between Patient and Control Groups

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Objective : There is still debate about the diagnostic efficacy of digital infrared thermographic imaging(DITI), nevertheless, it has been used for the diagnosis of carpal tunnel syndrome(CTS). We performed comparative study between patient and control groups to investigate the diagnostic value of DITI in CTS.

Methods : We studied 27 patients with electrodiagnostically-proven CTS and 18 symptom-free volunteers as a control. We measured thermal difference on DITI in the corresponding regions of the hands and forearms. We statistically analyzed the thermal data using a t-test.

Results : The average thermal difference in the diagnosed patient group ranged from 0.0303°C to 0.2856°C, while that in control group ranged from 0.0611°C to 0.2878°C. In the CTS patient group, thermal difference between each 2nd finger was higher than that of other regions. However, there was no statistical significance between patient and control groups.

Conclusion : We found that the diagnostic value of DITI in CTS was not sufficient. There should be a reconsideration of the usefulness of DITI in CTS.

KEY WORDS : Carpal tunnel syndrome · Thermography · Diagnosis.

Introduction

Carpal tunnel syndrome(CTS) is a disease generated by the compression of the median nerve in the carpal tunnel, which has various etiologies. This disease is common in the middle-aged women who mainly do the household[22]. In recent years, the range of patients has broadened to men and the youth as a result of the popularization of personalized computers at work and life as a whole[15].

Detailed history taking and physical examination are the most important in the diagnosis of CTS, and electrophisiologic studies such as electromyography and nerve conduction study are commonly used as the diagnostic test. However, the invasiveness of these studies causes the patient to complain of discomfort and in the case of the patient with an overlap of peripheral neuropathy from various causes, there is a disadvantage of difficulty in the interpretation of the result[3].

In addition, methods to observe the cross-sectional area of the median nerve in CTS using ultrasonography have been introduced, but the diagnostic criteria are uncertain[13,14]. There has also been a report of diagnosing CTS through magnetic resonance imaging(MRI) of the anatomical change in the carpal tunnel[10,12,17], but it is not widely used due to the expensive study.

Digital infrared thermographic imaging(DITI) which is universally used in the diagnosis of various neurological diseases, has the advantages of easy and simple examination, noninvasiveness, and ability to retrieve the saved image at anytime. Therefore, it is widely used in the diagnosis of CTS, but there was a controversy regarding its diagnostic value[8,11,22,25].

We conducted thermographic examination in the electrodiagnostically-proven CTS patients and symptom-free volunteers to investigate diagnostic accuracy of thermography.

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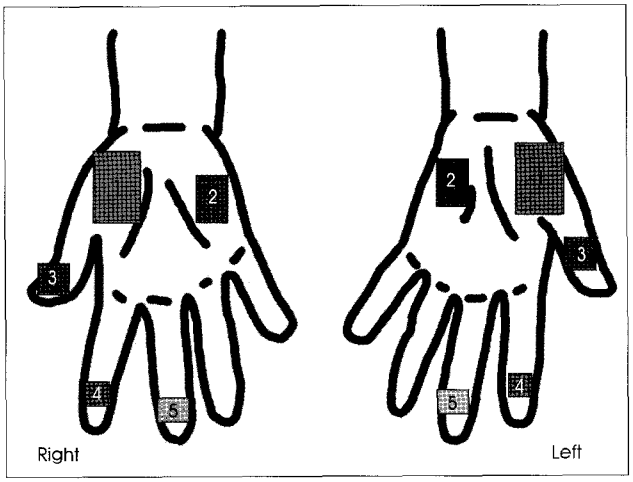

Fig. 1. Diagram of palm showing the designed regions divided into 5 parts. The authors measured thermal difference between each side to be equal in number.

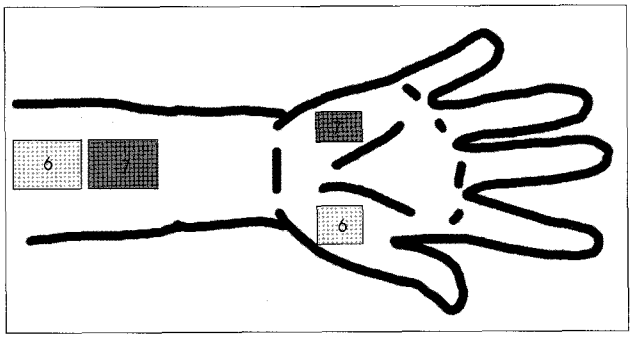

Fig. 2. Diagram of forearm showing the designed regions divided into 4 parts. The authors measured thermal difference between each side to be equal in number.

Materials and Methods

Among the patients who underwent operation of CTS between January 2003 and February 2004, those who do not have associated neurological disease and are diagnosed unilateral CTS from clinical history, physical examination, and nerve conduction study were classified into the patient group. The control group was intended for the asymptomatic middle-aged women and DITI was carried out the same way as it was operated on the patient group and the results were compared to each other. Thermographic examinations were performed with a commercially available thermography unit (IRIS 5000, Medicore Co. USA). All of the subjects underwent thermographic examination after each subject was allowed to undress and equilibrate with room temperature between 20 and 23°C for 15 to 20 minutes.

We measured skin temperature in the fingertips of the thumb, index finger and middle finger, and thenar and hypothenar areas of each hand (Fig. 1) and compared it between corresponding regions of the two sides in each subject. Skin temperature was also measured in radial and ulnar regions of distal forearm (Fig. 2) and interside temperature difference between symptomatic and asymptomatic hands was checked.

Table 1. Average of interside difference in skin temperature(℃)

	Patient group	Control group
Thenar	0.0392±0.6705	0.1311±0.6354
Hypothenar	0.1637±0.6115	0.1594±0.5679
1st digit	0.0698±1.3340	0.2878±0.9034
2nd digit	0.2856±1.0983	0.0611±0.6234
3rd digit	0.1356±1.2422	0.0728±0.7857
Volar-thenar	0.0303±0.3144	0.0614±0.6123
Volar-hypothenar	0.1682±0.8996	0.0612±0.8415

Table 2. Number of cases with thermal difference exceeding 1℃

	△ T > 1℃			
	Patient group		Control group	
	No. of cases	Percentage(%)	No. of cases	Percentage(%)
Thenar	2	7	2	11
Hypothenar	2	7	1	5
1st digit	6	22	7	38
2nd digit	7	26	3	17
3rd digit	9	33	3	17
Volar-thenar	3	11	2	11
Volar-hypothenar	6	22	3	17

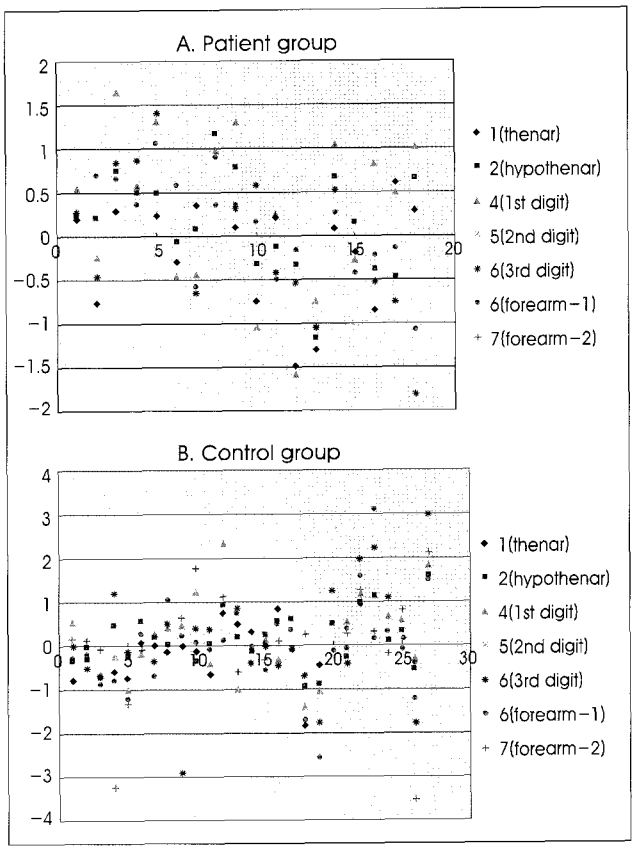

Fig. 3. Distribution of thermal difference over the each designed regions. Most data were ranged from −1 to +1℃, and there was no significant differences between the two groups.

Temperature differences between the patient and control groups were compared using t-test. P-value less than 0.05 was considered statistically significant.

Results

The patient group composed of 27 patients : 4 males and 23 females. The age distribution was from 33 to 68 years and the mean age was 50.4 years. Out of the symptomatic hands, 20 were right and 7 were left. The control group was all female, the age distribution was from 46 to 63 years and the mean age was 55.5 years. The mean and standard deviation of the temperature difference between corresponding regions of the two sides is displayed in table 1 and there was no statistically significant result to be observed between the two groups. Table 2 displays the example where the regional temperature difference was more than 1℃. Setting this as a standard, the sensitivity of the test was 41% and the specificity was 43%. Among the patient group, there was a tendency toward showing more change in the temperature difference between each second finger compared to other regions(Fig. 3), but this is also of no statistical significance.

Discussion

DITI is a technique of imaging an infinitesimal quantity of infrared electromagnetic energy released naturally from the skin surface in proportion to body temperature. This technique enables observation of change in body temperature caused by change in blood flow. Since Massopust[1] first attempted infrared thermography of human surface in 1948, DITI has been universally used in the diagnosis of vascular disorders such as varicose vein and deep vein thrombosis. Furthermore, its diagnostic value has been studied steadily in neuromuscular diseases that are presumed to have abnormality in the control of skin blood flow[18,21]. It is known that paralytic vasodilatation caused by sympathetic denervation appears on the skin of lesion of peripheral neuropathy[23]. Based on the result of digital plethysmography operated on CTS patients, Aminoff[1] confirmed that there is defect in the sympathetic outflow of the index finger. Pulst and Haller[21] performed thermographic studies in the patients with brachial plexopathies and found vasoconstrictive phase develops, presumably due to postdenervation hypersensitivity of blood vessels to circulating catchecholamine after vasodilatation period in the first 5 to 6 months. Such sympathetic denervation causing vasodilatation may account for skin temperature changes following a peripheral lesion.

Another mechanism for skin temperature changes in peripheral neuropathies is abnormal ectopic transmission from damaged nerve fiber. Comstock et al.[5] showed antidromic activation of unmyelinated pain fibers results in local warming in the distribution where the pain is felt, which may be due to release of substance P, a potent vasodilator, by the nerve endings. These kinds of studies support the diagnostic efficacy of DITI on patients of various neuropathy. It is well known that DITI is useful in the early diagnosis of reflex sympathetic dystrophy[2,17], and there has also been significant result in studies of entrapment neuropathy[8,21,22] and spinal disease such as herniated intervertebral disc[4,9,19].

The diagnostic reliability of thermography in evaluating patients with CTS is variable depending on the studies. There were favorable reports concerning thermography in CTS[8,11,25]. Herrick and Herrick[8] studied 55 patients with CTS and found sensitivity of 100% and specificity of 96% for thermography but there was no control group in this study. Tchou et al.[25] reported that thermographic observation in 61 cases with CTS revealed sensitivity ranging between 93% and 98%, and specificity between 98% and 100%. Kim et al.[11] also demonstrated favorable results in their study, comparing temperature difference of thenar and hypothenar area from forearm, respectively, but this study was limited because thenar area is innervated by palmar cutaneous branch of median nerve, which branched off before entering carpal tunnel[6,7,18,24].

On the other hand, Sunderland et al.[23] reported that the thermography results were abnormal in 12 of 22 patients with CTS. However, Meyers et al.[16] demonstrated no significant thermographic abnormalities in 9 cases of CTS with mild electrophysiologic abnormalities. They also discovered unequivocal thermographic changes in 7 out of 14 CTS with definite electrophysiologic abnormalities. This indicates thermography is not useful in the diagnosis of CTS, especially with equivocal or mild electrophysiologic abnormalities. We could not find any significant interside temperature differences in our study though there was a trend toward increased temperature difference in index finger. There are several theories explaining why thermography is ineffective on CTS patients. Thermography that does not take various forms of dermatologic variation into consideration accompanies error in the interpretation of the result. When CTS is accompanied by diseases such as Raynaud's phenomenon, neurosecretory neuropathy, and vascular occlusive disorder, complex changes occur on the somatocutaneous sympathetic reflex[16,22]. In such cases, it is difficult to observe and compare the atypical change in body temperature. In addition, So et al.[22] reported that thermographic abnormalities are not confined to the dermatome of the involved nerve because partial nerve injury may trigger spatially nonspecific autonomic reflexes, causing generalized vasoconstriction and therefore interpretation of thermogram is difficult. Moreover, frequent bilateral lesion of CTS could complicate the interpretation of interside difference.

Since pain in CTS is transient and mostly nocturnal, there may not be thermographic abnormalities when pain is not present at the time of thermography. For that reason, it is often encouraged to conduct 3 consecutive tests in 15-minute periods along with several tests of stress that induces the symptom[8,20]. So et al.[22] reported that they compared the results of thermography from CTS patients of example 8 depending on whether Phalen's maneuver was operated before the examination and that no significant difference was observed. However, consecutive testing is very time intensive, defeating the advantage of a simple and easy thermography. In other words, the stress test ends up being inefficient.

Conclusion

Thermography is an easy, simple, non-invasive method to evaluate CTS. However, it could not be as useful and sensitive as electrophysiologic studies in the diagnosis of CTS.

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Commentary

The authors investigated the usefulness of thermography in diagnosis of carpal tunnel syndrome(CTS), one of the most common peripheral entrapment neuropathy. They organized their results well with relevant literature review, although the result was negative.

Despite various attempts to develop a new diagnostic modality, electrodiagnostic study remains as a gold standard for diagnosis for CTS[1]. Digital infrared thermographic imaging (DITI) has the advantages of easy and simple in operation and less invasiveness, and would be a good diagnostic tool if it shows high sensitivity and specificity. However, the authors's investigation revealed that the diagnostic value of DITI in CTS was not sufficient, which is not surprising in consideration of diverse results on reported articles. DITI might have a role as supporting tool in equivocal cases, rather than as a primary one.

Although concise and well-organized, there are a few missing points in this study. If they had grouped patients according to findings of electrodiagnostic studies, the goal of this study would have been fulfilled more adequately. The process of picking out control group had to be refined in detail : criteria for selection, required number of controls. This process would require consulting to an expert in biostatistics.

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