Clinical Article

Validation of Thermography in the Diagnosis of Acute Cervical Sprain

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Objective : The diagnosis of acute cervical sprain was done based on rigidity in the cervical area on X-ray and the symptoms reported by the patient so that it was difficult to differentiate those patients who complain of cervical sprain for an secondary gain. Thus, the present study is done for differential diagnosis of those fake patients who want the diagnosis of cervical sprain for the purposes of financial gain using the thermography, which is effective for objectifying pain by detecting the change in body temperature in the area of pain.
Methods : This study was done in 327 patients who were admitted to the neurosurgery department at Chosun University Hospital between January 1, 2001 to January 31, 2002, mainly complaining of cervical pain from traffic accidents. According to the previous methods of diagnosis, the presence of rigidity in the cervical region was determined on X-ray and this result was compared with the result from thermal imaging.
Results : When the verbal numerical rating scale of patient's subjective pain was classified into severe, moderate and mild, cold spot and disruption of normal thermographic shape increased significantly on thermal imaging as the severity of pain increases.
Conclusion : Thermal imaging is not only effective for differentiating the presence or absence of cervical pain but also for determining the pain severity, fake patients, and pain recovery.

KEY WORDS : Cervical sprain · Thermography · Secondary gain · Thermographic shape.

Introduction

Cervical sprain is one of the most frequently made diagnosis by neurosurgeons since most patients involved in automobile accidents want the diagnosis of cervical sprain whose financial gain would differ by whether the diagnosis of cervical sprain is made or how long the treatment should last. Moreover, it is difficult to deny the fact that the diagnosis and treatment period differed according to each doctor because the diagnosis of cervical sprain has been based only on simple x-ray of the neck and patient complaint. In other words, we lack objective tools to evaluate cervical sprain so that doctors sometimes face difficulty mediating between the automobile insurance company and the patient in some cases.

The concept of pain includes physical, emotional and behavioral aspects. Individuals recognize and respond very differently to pain and pain could be expressed differently according to emotional and environmental factors. Thus, it is difficult to trust each patient's testimony as is over pain when insurance is involved in auto accidents or industrial accidents. Furthermore, the degree of pain complained and degree of tissue damage do not agree in these patients.

Thermography is a tool diagnosing abnormal areas in the body by measuring heat emitted from the skin surface and expressing the measurements into a thermal map. After LeoMasspont took UV images for the first time in 1948, Lawson applied this tool clincially in the diagnosis of breast cancer in 1956[11]. Later, it was used to diagnose and screen various diseases, and researchers reported that thermography could be used to objectively observe functional aspect of various diseases including pain[3,22]. After Duensing used thermography for the first time clinically for neuromuscular diseases in 1973, thermography was determined to be the only tool that could visualize muscular status in musculoskeletal disease by quantitatively evaluating the physical status of pain.

This study was performed to evaluate whether thermography could be used to diagnose cervical sprain or the severity of neck pain to see the effectiveness of this tool for the differential diagnosis of patients claiming cervical sprain for a secondary gain.

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Materials and Methods

We examined 327 patients who were admitted at Chosun University Hospital through the department of

neurosurgery from January 1, 2001 to January 31, 2002. In order to minimize the reflection of patients' subjective symptoms, these patients were those who were admitted via emergency center, excluding those who came to the outpatient clinic for the purpose of being admitted 1~2days after the accident. We also exclude those who we suspected through an interview to have gotten admitted for the purpose of receiving insurance coverage. In order to reduce thermograph error, we excluded those patients with cervical injury and those who were menstruating or had infectious diseases. Thermography was taken the day after injury in most cases without giving any fluid or medications to the subject starting the night of receiving injury. In the test room protected from light and heat, the temperature was maintained between 20~23°C since blood vessels constrict under 17°C and evaporation due to sweat occurs at temperatures higher than 25°C[16]. Humidity was maintained at 35~45%. The subject was asked to take off the top garment and stay stripped for 15 min to get used to the room temperature. Then, thermography was taken with the patient sitting from the back, and when necessary, from the front or side.

The patient was asked to record pain score before the test and to mark the parts of the body hurting. We then recorded the course of accident and subjective pain as the patient described them and the presence of radiating pain. Cervical X-rays taken in all patients were compared with cervical rigidity and thermographs. Thermographs obtained from these patients and 63 normal controls having no cervical pain.

Thermography was taken from the back of the neck along the vascular network pattern as close to the normal pattern of the central thermograph line as possible. We recorded the expression of cold spots in areas different from the areas where the patient indicated to have pain between the patient group and control group by comparing the thermographs and a disarrayed pattern of normal vascular network. The color in the vascular network pattern only indicates relative temperature, not the absolute temperature. We did not compare the temperature difference between both sides of the neck since pain mainly shows along the midlines of the cervix in the cervicothoracic region in patients with cervical sprain. We compared temperature differences in the opposite side showing normal color only when cold spots were seen in one side of the scapula or trapezius muscle. According to patient complaints, the severity of pain was divided into severe pain (verbal numerical rating scale 10, 9, 8 points), moderate pain (verbal numerical rating scale 7, 6, 5), and mild pain (verbal numerical rating scale 4, 3, 2, 1) to analyze the expression of cold spots, normal vascular network pattern disarray, and normal thermographs. Furthermore, sprain in cervical lateral radiography from the neck was investigated in each group to compare changes in thermal maps. Images were taken using IR-2000 (Medicore Co.).

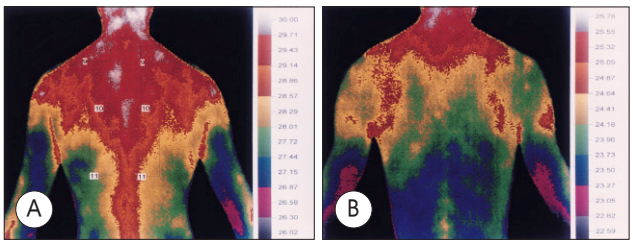

Fig. 1. Normal thermographic shape. A : lozenge shape with central continuity line, B : Not lozenge shape but symmetric shape.

Results

Thermography was taken from 63 normal controls without cervical sprain in which 55 (87.3%) showed normal finding and 8 (12.7%) showed no pain but abnormal thermal maps, showing two different thermal map groups (Fig. 1). Type Ⅰ, lozenge shape with central continuity line included 38(69.1%). Type Ⅱ, not lozenge shape but symmetric shape included 17(30.9%). Out of 8 who showed abnormal thermal maps, 5 patients showed cold spots, among whom cold spots were probably from thick soft tissue in the cervicothoracic region in 2 patients, needing caution when making the reading (Fig. 2). And 3 patients showed disarrayed pattern of normal vascular network.

A total of 327 patients were included in this study, among whom 196 (59.9%) were men and 131 (40.1%) were women, showing more men who were socially active. The average age of the patients was 37.7 years. The pattern of pain was vague in which the patients could not tell where the painful areas were exactly, using the words such as stiffness, swollen muscle, and contracture to describe the pain. Other words to described pain were sharp and stingy pain, pain as if opening a wound, and soreness. Most complained of persisting pain rather than intermittent pain. Radiating pain was present in 185 (56.6%), mainly in the scapula(80%), followed by anterior chest (13%) and occiput(7%).

When pain was given a score, 6 gave 9 points; 94, 8 points; 9, 7 points; 151, 6 points; 11, 5 points; 32, 4 points; 18, 3 points; and 6, 2 points. When we defined the sever-

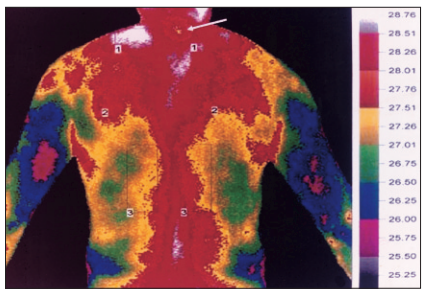

Fig. 2. Cold spot (arrow) due to thicked skin or connective tissue.

ity of pain as severe for the scores of 9 and 8 points, moderate for the scores of 7, 6, 5 points, and slight for the scores of 4, 3, 2 points, severe pain was present in 100 patients (30.6%), moderate pain in 171 (52.3%), and slight pain in 56 (17.1%) (Table 1).

According to simple radiography of the neck taken from the lateral side, rigidity was seen in 91 patients (91%) in severe pain group, in 124 (72.5%) in moderate pain group, and 31 (55%) in slight pain group. Thus, cervical rigidity increased with increasing severity of neck pain. The presence of rigidity was diagnosed by two radiology specialists (angulation>9°, interspinous diameter>11mm).

Thermographs showed cases with a simple disarrayed pattern of normal vascular network (Fig. 3A), those with cold spots (Fig . 3B), and those cases showing both disarrayed pattern and cold spots. As the severity of pain increase, the frequency of cold spots and disarrayed pattern of normal vascular network was high. Both findings were seen in many cases especially in those patients with severe pain (Fig. 3C). Normal thermograph pattern was seen in 5 (5%) in severe pain group, 25 (14.6%) in moderate pain group and 6 (10.7%) in slight pain group, showing many patients with moderate pain showing the normal pattern (Table 2).

When the temperatures in cold spots and same thermatome were compared, the average difference was 0.87°C In those cases that showed only a disarrayed pattern of normal vascular network, the average temperature difference was 0.44°C compared with same thermotome.

Table 1. Classification of patients

Verbal numerical rating	scale	Patient No.	Total
Severe group	10	0	100
	9	6	
	8	94	
Moderate group	7	9	171
	6	151	
	5	11	
Mild group	4	32	56
	3	18	
	2	6	
	1	0	

Table 2. Thermographic finding

Thermographic finding	Severity of pain		
	Severe (n=100)	Moderate (n=171)	Mild (n=56)
Only Cold spot	28(28%)	51(29.8%)	13(23.2%)
Only disruption of normal thermographic shape	16(16%)	47(27.5%)	28(50.0%)
Cold spot+Disruption of normal thermographic shape	51(51%)	48(28.1%)	9(16.1%)
Normal thermographic shape	5(5%)	25(14.6%)	6(10.7%)

(SPSS 11.0version chi-square test P-value < 0.001)

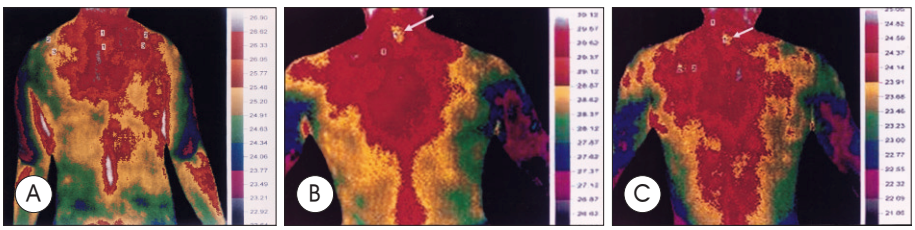

Fig. 3. A : Disruption of normal thermographic shape, B : Cold Spot (arrow), C : Cold Spot (arrow) + Disruption of normal thermographic shape.

Discussion

Cervical sprain describes injury of soft tissues surrounding the neck through a complex action of extension and flexion forces and only includes injury to the supporting ligament of soft tissue but not main ligament[15]. Clinically, cervical sprain is diagnosed when no cervical injury is seen on X-ray but neck pain is present without no nerve root injury according to physical examination[2].

The diagnosis of cervical sprain has to be based on patients complaint. Most patients obtaining the diagnosis of cervical sprain are people involved in automobile accidents but the diagnosis based on patient complaint is problematic since these people receive insurance compensation based on the diagnosis and the period of hospital stay. Nonetheless, there is no definite method to confirm the diagnosis of cervical sprain in those patients who want longer hospital stay for compensation or those who complain persisting neck pain due to psychosomatic disorder. In addition, the court or the insurance company want clear objective data in many cases. Thus, the patient has to objectively prove the diagnosis.

Although DITI(Digital Infrared Thermal Imaging) is well built in most cases, there are some debates in the clinical application of this machine. Harper et al. reported that the diagnostic value of these machines for neuropathy is less than 50%[8], and So et al.[17] reported that thermography has less diagnostic values since it gives different results compared with clinical findings or results from electromyography. McCulloch et al.[14] also reported that the sensitivity of thermography is 50~60% and specificity is 45~48%, lagging diagnostic value. Nonetheless, thermography is used extensively to screen and evaluate the prognosis and treatment outcomes of various musculoskeletal and neurologic diseases such as herniation of the nucleus pulposus, breast cancer, and myofascial pain syndrome[3,6,14,22].

The skin is an important organ controlling body temperature through the vast vascular network and the nerve network that control

circulation within several millimeters of the skin surface. The sympathetic nerve system affects skin surface perfusion and the actions of this nerve system include spinal parasympathetic nerve action, stimulation of sympathetic nerve for vascular expansion, and partial control by sympathetic nerve reflex[4,5]. Furthermore, the temperature on the skin surface is maintained by equilibrating heat introduced onto the skin and heat emitted from the skin surface. There are 3 types of heat introduced into the body, i.e, heat introduced by blood circulation, heat produced by tissues, and heat entered into the center of the body by conduction[12,13]. The factors such as the vascular distribution on the skin, autonomic nervous system factor controlling vascular circulation, factors locally controlling heat production according to pathophysiology especially the muscular system affect skin temperature. Other factors also affecting skin temperature are the age, gender, mental status, individual intrinsic factors, environmental factors, humidity, season, and time of measurement[1,20].

In 1980 Pierre LeRoy defined the region related with the autonomic nervous system of skin vascular network as a thermatome[9]. A complete thermatome is composed of 3 components, i.e., dermatome, myotome and sclerotome composed of bone, joints and ligaments. Furthermore, this thermatome has a common nerve circuit[10]. Most diagnosis using thermagraphs have been based on temperature differences in the left and right thermatomes[3,21]. However, the diagnosis of cervical sprain using thermatomes is impossible. Cervical sprain itself is due to injury in the spinous process, or transverse process ligament and its surrounding muscle tissues, rather than nerve injury according to each thermatome. Pain usually develops along the midline of the body in cervical sprain so that comparing temperature difference in thermatomes in both sides of the body does not have any significance.

Many authors examined thermography on its possible application in the diagnosis of different diseases. Gautherie and Gros classified breast thermographs from Th-Ⅰ to Th-Ⅴ according to the symmetry of thermography pattern, presence of hot regions, abnormal pattern of vascular network, and degree of temperature difference[6,7]. Sterns and Zee also reported that symmetric finding with one side of the breasts showing avascular or slightly vascular pattern while no hot spot findings in breast thermography would be considered normal, whereas abnormal breast lesion is suspected when the temperature difference was more than 2°C while local vascular network pattern is seen in the lesion, and abnormal would be defined when the temperature difference was more than 3°C with the site of the lesion showing severe vascular abnormality[18]. Urematsu et al. stated that pathophysiological changes are present when temperature differences are seen along in the thermatome with bilateral symmetry, when temperature differences are asymmetrical within the same thermatome, and when local cold spots or hot spots are present[19].

It is difficult to apply the previous methods of using thermographs in the diagnosis of cervical sprain. Most of 327 patients with neck pain described their pain with the words such as stiffness and muscle contracture and could not locate the exact spots of pain, showing radiating rather than isolated pain. Hot spots did not correlated with pain areas so they could not be viewed as the spots originating pain or spots related with pain. In cold spots (most in the trapezius muscle or cervicothoracic area) agreed with the areas where the patients with cervical sprain indicated to have pain, an average temperature difference of 0.87 was seen by comparing with the normal vascular network pattern. Thus, cervical sprain could have these characteristic themographs. Furthermore, the normal vascular network was significantly disarrayed in the areas where the patients reported to have pain. In these areas, the average temperature difference was 0.44 compared with the normal vascular network pattern. The frequency of these increased as the severity of subjective pain increased along with the emergence of cold spots. Especially in those patients with severe pain, the frequency of cold spots and disarrayed pattern of normal vascular network was high, suggesting that both findings would indicate severe pain.

The number of people showing normal thermagraphs were high in moderate pain group (14.6%) compared with slight pain group (10.7%). We believed that this result was probably because many of those fake patients marked their verbal numerical rating scale with the score of 6; however, we could not obtain accurate statistical results. Cold spots were seen in the cervicothoracic region in some patients with no neck pain due to a thick layer of soft tissue in the cervicothoracic region. In these subjects, differential diagnosis were possible since the cold spots had relatively distinct margins, were round or oval, and were located in the midline of the body (Fig. 2).

According to plain radiography, cervical rigidity was seen in 91% of severe pain group, 72.5% in moderate pain group, and 55% in slight pain group, showing increasing rigidity with increasing pain. Compared with thermography abnormality seen in 95% in severe pain group, 85.4% in moderate pain group, and 89.3% in slight pain group, plain radiography significantly lagged in diagnostic sensitivity. Furthermore, ridigity was present in 55% of the patients with slight pain, suggesting that plain radiography would not actually reflect pain. Thermography showed more than 85% diagnostic sensitivity for neck pain. The number of people with cold spots and disarrayed pattern of vascular network increased with increasing neck pain. Only the disarrayed pattern of normal vascular network was seen in patients with slight neck pain.

It would be difficult to diagnose cervical sprain only with thermography. However, we could decide whether to diagnose cervical sprain by examining whether the area of pain that the patient is complaining agree with the finding from thermography and the presence of rigidity in the neck on X-ray and could predict the severity of pain. Furthermore, thermography would be effective in deciding to extend hospital stay.

Conclusion

The following are the benefits of thermography in patients with cervical sprain.

1) Thermography would be effective in the differential diagnosis of those patients who want the diagnosis of cervical sprain for ulterior motives such as financial gain through insurance claim. 2) It was effective in the diagnosis of neck pain during recovery and the severity of neck pain. 3) It could be used to cut the cost of medical care by determining whether MRI would be needed. It is non-invasive so that it could be done safely and repeatedly. The data collected could be stored so that they are reproducible and data storage is easy.

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