Thermographic Diagnosis of Whiplash Injury with/without Radiculopathy

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Objective: Whiplash injury is produced by the hyperextension of the neck followed by flexion. Symptoms are neck, shoulder and occipital pain. Some of them complain the radiating arm pain. These patients have no abnormality in radiologic evaluation. But symptoms are true and recovery is also evident.

Materials & Methods: ① Whiplash injury with/without radiculopathy can be diagnosed in early stage and, ② the possibility to differentiate the whiplash injury with radiculopathy and pre-existing herniated cervical disc and, ③ the thermal changes are recovered with symptom improvement.

We collected 39 patients and divided into two groups. Group 1 was neck pain without radiculopathy (30 patients). Group 2 was neck pain with radiculopathy (9 patients). Thermal differences at neck and arm were checked with IR thermography. 1 patient was taken the IR thermography periodically until recovery from his symptom.

Results: Subjective painful area on the neck was changed to hyperthermic than control group. The temperature of the arm was normal. Results of group 2 were as follows; subjective painful area on the neck was changed to hyperthermic than control group. Painful arm was changed hyperthermic, which can be differentiated from hypothermic change in cervical disc herniation patients. Thermal differences were gradually reduced with the same consequence of patients' symptom recovery. This showed a good correlation between the subjective pain scale and thermal differences during the recovery periods.

Conclusion: IR thermography can be used to diagnose the whiplash injury and also to be used to determine the symptom recovery. It is possible to differentiate the whiplash injury with radiculopathy and pre-existing cervical disc disease.

Key Words: IR thermography · Whiplash injury · Pain chart

INTRODUCTION

Acceleration-hyperextension injuries were originally described in 1867 associated with railroad accidents[1]. So, the mechanism of whiplash injury is produced by the hyperextension of the neck followed by flexion. Symptoms are neck, shoulder and occipital pain. Some of them complain the radiating arm pain, dysthesia and/or weakness, sensory loss in cervical dermatome. And few patients also complain brain symptoms like as dizziness, vestibular dysfunction and dysphagia. These patients have no abnormality in radiologic evaluation. But symptoms are true and recovery is also evident.

Anatomically injured areas have been proved many sites around the neck as zygoapophyseal joint, intervertebral discs, anterior longitudinal ligament, pedicles and laminae, atlantoaxial complex, muscle tear and strains, second cervical dorsal root ganglion, etc.[2].

In the epidemiologic consideration, increases of the amount of cars and traffic jam make more minor traffic accidents rather than major life-threatening accidents. Even though the incidence of whiplash injury is increasing, no accepted study dealt with the value of history taking, physical examination, plain radiographs, specialized imaging technique, and special examinations for the positive diagnosis of whiplash injury[3].

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Infrared thermography is using in the medical field to detect skin temperature and analyze the disease pathophysiology. We designed and analyze the skin temperatures of the whiplash patients to find out the possibility of the diagnostic tools.

The purposes of this study are; ① whiplash injury with/without radiculopathy can be diagnosed in early stage and, ② the possibility to differentiate the whiplash injury with radiculopathy and pre-existing herniated cervical disc and, ③ the thermal changes are recovered with symptom improvement.

MATERIAL AND METHODS

1. Equipment and Procedure

Thermography was taken with a Digital Infrared Thermographic Imaging (Dorex Inc, West Collins, CA, USA) device at 23℃ shielded from outdoor light and heat. The controls and patients were requested to undress and to remain in the laboratory for approximately 15 minutes and to stand to allow the skin surface temperature to adjust to room temperature. Thermograph was taken the trunk and arm at a distance 1.5 m and arm at 1 m distance.

2. Controls and Patients

Control group data was used from our previous paper, which was made from 50 healthy adults and temperature checks at 110 sectors in each person[4](Fig. 1).

39 patients were selected from the Spine Center of Yongdong Severance Hospital and NHIC Ilsan Hospital from Mar. 2004 to Feb. 2005. They were divided into two groups. Group 1 was neck pain without radiculopathy (30 patients). Group 2 was neck pain with radiculopathy (9 patients). Thermal differences at neck and arm were checked with IR thermography. 1 patient was taken the IR thermography periodically until the recovery from his symptom. All patients draw his subjective pain site and pain scale on the pain chart when he took the IR thermography.

RESULTS

Results of group 1 (neck pain only) were as follows; subjective painful area on the neck were changed to hyperthermic than contralateral aspect. Mean temperature difference between painful side of neck and contralateral aspect is 1.25±0.79℃. Temperature difference between arms (0.15±0.11℃) is within normal distribution when compared with control group.

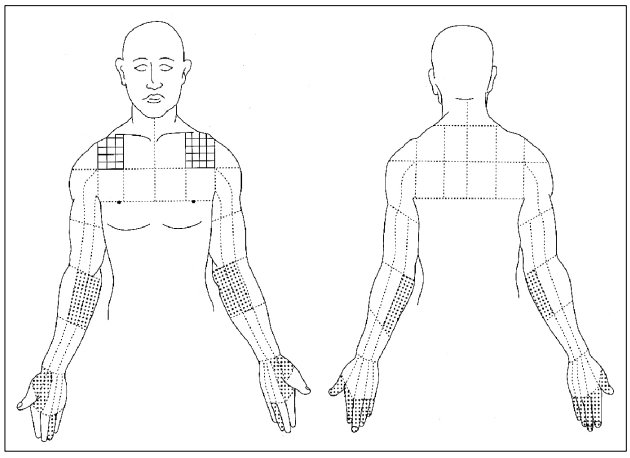

Fig. 1. Minimal abnormal thermal difference between right and left side sector with 99% confidence interval ($p<0.01$)[4]. Crossed sector: if ΔT in this sector is more than 0.1℃, we can define it was abnormal thermal difference. No marking sector: if ΔT in this sector is more than 0.2℃, we can define it was abnormal thermal difference. Dotted sector: if ΔT in this sector is more than 0.3℃, we can define it was abnormal thermal difference.

Results of group 2 (neck pain with radiculopathy) were as follows; subjective painful area on the neck were changed to hyperthermic than contralateral aspect. Mean temperature difference between painful side of neck and contralateral aspect is 0.43±0.37℃. Painful arm was changed also hyperthermic (0.93±0.83 ℃) than contralateral aspect (Fig. 2).

All thermographic examinations were done at the patients' first visiting day. 37 patients among 39 were come within one week from accident, and two patients were come after 1week. All 39 patients had an abnormal hyperthermic change at the painful neck area. All group 2 patients revealed hyperthermic change at the painful arm(Table 1).

One patient had been taken the thermography four times until his symptom was subsided. This showed the gradual decrease of thermal differences of neck and arm, and subjective pain score. Final thermography was taken 6 months after trauma, and his subjective pain score was 2 (much improved, but still not fully recovered) and his arm was still abnormal even though his neck

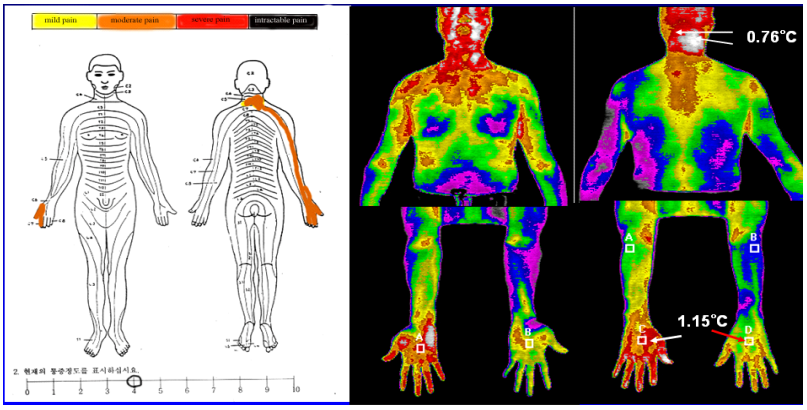

Fig. 2. Patient's self-drawn pain chart and IR thermography of group 2 (whiplash injury with radiculopathy) case. He complained posterior neck and radiating right arm pain. His right side of the neck was abnormally hyperthermic (0.76℃ higher than left side) and right hand was also abnormally hyperthermic (1.15℃) than control group data.

Table 1. Temperature differences in each group

	Group 1	Group 2
Number of Patients	30	9
ΔT_{Neck}	1.25±0.79℃	0.43±0.37℃
ΔT_{arm}	0.15±0.11℃	0.93±0.83℃
Thermograph < 1 week of trauma	28 patients	9 patients

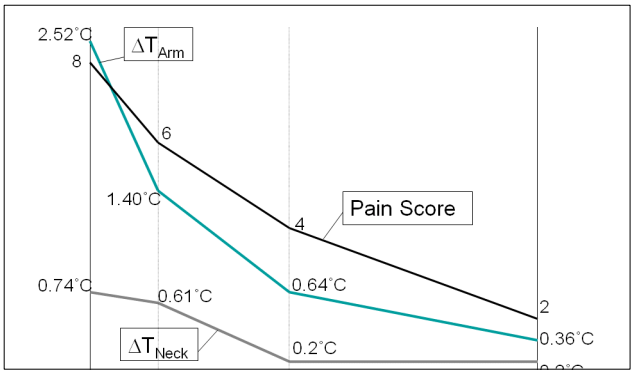

Fig. 3. Chronological changes of subjective pain score and thermal differences. One patient was following up and took IR thermography serially. His subjective pain score was improved from 8 (3 days after trauma) to 2 (6 months after trauma). The thermal difference of the neck (ΔT_{neck}) was also improved within normal range (0.2℃) at 3 months after trauma, but his thermal difference of arm (ΔT_{arm}) was improved but still abnormal thermal difference same as his remained subjective pain.

was normal temperature range(Fig. 3).

DISCUSSION

Whiplash injury without radiculopathy (group 1) could find the abnormal hyperthermic change at the painful sector of the neck in the IR ther- mography. This hyperthermic change can be ex- plained by the local inflammatory reaction. Hyperextension followed flexion on neck makes the strains on neck muscle and ligaments. These injured soft tissues provoke the inflammatory reaction at the lesion and leads to increase the local blood flow. Temperature distribution of the arm was normal because there was neurolo- gically innocent and no other effect on the arm. All of group 1 patient detected thermal abnormality at the first visiting time.

Whiplash injury with radiculopathy (group 2) could find the abnormal hyperthermic change at the painful sector of the neck and also involved arm in the IR thermography. This pattern was same as the thermatomal distribution of the cervical nerve roots [4]. But it was obviously different from hypothermic change in herniated cervical disc disease[5]. We can differentiate the diagnosis of herniated cervical disc disease and whiplash injury, and can determine whether a symptom aggravation of pre-existing herniated disc disease before trauma or a newly developed whiplash injury with radiculopathy.

The pathophysiology of this hyperthermia is still unknown.

But we can presume the sympathetic denervation effect along the cervical nerve root distribution. Because, in the cervical disc herniation, herniated disc compressed nerve root and sympathetic fibers in the nerve root are exited and leads to decrease the cutaneous blood flow on the thermatomal area. This makes the hypothermic arm[5]. In the whiplash injury with radiculopathy, hyperthermic arm might be due to denervation of nerve root or sympathetic fiber. Nerve root is not damaged pathologically, we can presume that sympathetic fiber's action is ceased. Thermography of the patient who had sympathetic block due to discogenic pain or sympathectomy due to palmar hyperhidrosis (over-sweating hands) show the same patterns of hyperthermia as this whiplash injury.

Recovery from the whiplash injury shows gradual decrease of the temperature differences and pain scale as the same curve. This means IR thermography can also detect the recovery state of the whiplash injury. Even though we followed 1 patient chronologically, the correlation between pain scale and IR thermography in whiplash injury may be a significant correlation as our previous report[6].

CONCLUSIONS

IR themography of the whiplash injury without radiculopathy (group 1) shows the hyperthermic change at the subjective painful site on neck and normal thermal distribution in arm. IR thermography of the whiplash injury with radiculopathy (group 2) shows the hyperthermic change at the involved arm along the cervical thermatome. This hyperthermic change can be differentiated whiplash injury from herniated cervical disc disease. IR thermography can be used for the detection of whiplash injury at early time of trauma and also for following up the improving state of pain.

IR thermography can diagnose the whiplash injury in early stage, can differentiate the whiplash injury with radiculopathy and pre-existing herniated cervical disc disease, and can detect the symptom improvements.

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