Study on the Skin Temperatures of the Orofacial Trigger Points for the Patients with TMJ disorders

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CONTENTS

Ⅰ. INTRODUCTION

The skin, one of the largest organs of the body, is equipped with a network of vessels accompanied by dense nerve fibers. It serves as the bodys thermoregulator, controlling blood flow within a few millimeters of the body surface.[32] The system is governed by autonomic nerve impulses generated from the hypothalamus and the brain as a whole. The system is both anatomically and physiologically symmetrical.[28] For this reason, localized, asymmetric temperature changes at the body surface have interested physicians as far back as Hippocrates.[34] Thermography is the process of recording surface skin is nearly a perfect emitter of infrared energy reflecting body surface temperatures.[19] Since any object that emits heat also emits infrared radiation in proportion, it is possible to measure the temperature of the skin by measuring the infrared output. If the instrument is sensitive enough, different gradations of temperature which have clinical significance can be recorded. These simple facts are the basis of thermography, which is now under wide experimentation in the field of medical radiology.[4] Sir William Herschel is credited with the discovery of infrared radiation, but proof of its existence is ascribed to his son, Sir J.F.W. Herschel, who succeeded in recording these wavelengths on paper, thereby introducing the term thermograph.[1] Hardy and associates[18-20] showed that it was practical to make thermograms of human skin.

If an individual is physiologically normal, i.e. healthy, then the temperature of the skin surface should be bilaterally symmetrical for any given area of the body. Uemastu *et al.*[33] analyzed in detail the thermal symmetry of healthy subjects and found that the difference between left versus right over the trunk was only 0.17 ± 0.042℃. Even on the fingers and toes, areas which may parallel ambient temperatures, the difference was still only 0.45 ± 0.13℃.

Pathological conditions in joints and muscles are often associated with circulatory disturbances and/or inflammatory reactions located in the synovial membrane of the joint, the tendons, and the connective tissue in muscles and bone.[36,37] When these processes are close to the surface of the body, they influence the skin temperature, which can be measured by thermography.[6,23] Measurements of skin surface temperature may be useful in the assessment of disease activity and progress and in evaluation of treatment results, which otherwise is largely based on subjective observations.[21]

The most widely studied application of thermography to the orofacial region has been in the characterization of craniomandibular disorders, particularly temporomandibular joint(TMJ) dysfunction. In 1971, Berry and Yemm reported that the temperature overlying an area of tenderness in the masseter muscle was higher than that of the same area on the contralateral side.[2] Some researchers assessed the temperature characteristics of the TMJ, temporalis anterior and masseter muscle in a normal population. By using thermistors, they reported differences of only 0.3℃ and 0.4℃ for left versus right for the TMJ and masseter muscle, respecitively.[22] Song et al. evaluated the reproducibility of temperature measurement over the temporalis anterior and the masseter muscle using thermistors in normal individuals and found that the temperature difference for left versus right was less than 0.3℃.[30]

The recent development of sophisticated thermographic measuring devices that can provide a map of the temperature of the body surface has increased this interest.[35]

Recently, ET has emerged as a promising diagnostic tool for patients with chronic orofacial pain.[7,8,10,12] In addition, ET has been used to evaluate a variety of orofacial conditions, including TMJ disorders,[3,11,14-16,26,31] maxillary sinus disease, and inferior alveolar nerve damage (traumatic neuralgia) subsequent to orofacial trauma or surgery.[9]

Gratt *et al.* assessed infrared thermography (IRT) as a diagnostic modality for internal derangement of the TMJ and found its sensitivity and specificity to be 86% and 78%, respectively.[13] In 1999, Han[17] demonstrated that facial temperature symmetries were within 0.1℃.[38] In the study using a infrared thermography. He attached ring-like markers in the skin of the trigger points to find the location easily in the monitor and reported that infrared thermography has some promise as a diagnostic aid in the evaluation of orofacial pain.

This study is aimed at comparing the skin temperatures of trigger points in the masseter, temporal muscles and TMJ of the symptom and symptom-free sides of faces for the patients with temporomandibular disorders, using a digital infrared thermal imaging, to show TMJ disorders and myogenic facial pain produce asymmetric patterns on digital infrared thermograms of the face and to prove to be helpful in objectively monitoring the results of therapy for TMJ and myogenic pain.

Ⅱ. MATERIALS AND METHODS

1. Subjects

During a 3-month period, 30 patients with temporomandibular disorders referred to the Orofacial Pain Clinic of the Dental Hospital of Dankook University performed thermographic imagings. Among them, 9 were excluded in this study for they had no pain or had pain bilaterally in the masticatory muscles and TMJ. All 21 patients had pain and other symptoms at the time of thermographic imaging. Their symptoms were classified according to accepted criteria[24] as either predominantly those of internal derangement or inflammation of the TMJ, or as myogenic facial pain from the surrounding musculature(Table 1). The sites of muscle and joint pain were recorded.

Table 1. Sex distribution of patients classified according to diagnosis

subject	diagnosis			total
	acute muscle disease	chronic muscle disease	joint disease	
male	5	0	2	7
female	5	4	5	14
	10	4	7	21

2. Trigger points for temperature measurement

The trigger points recommended by previous researchers were used for the present study. Followings are the muscles (Fig. 1) and the methods used to locate the trigger points in the current study for infrared thermographic imaging:

1. TMJ: The area 1 cm anterior to the tragus of ear
2. Anterior temporal muscle: The subject is asked to clench and relax to help identify the muscle. The fibers above the infratemporal fossa and immediately above the zygomatic process are palpated.
3. Anterior masseter muscle: The subject is asked to clench while the masseter is observed for the location. Fibers of the anterior border are palpated immediately below the zygomatic arch.
4. Inferior masseter muscle: The area 1 cm superior and anterior to the angle of the mandible is palpated

3. Thermography equipment

Digital infrared thermal imaging was performed using DTI-16-DOREX21 (DOREX Inc. U.S.A.). Components of digital infrared thermal imaging (DITI) systems included an infrared scanner, control unit, thermal image computer, software, cables, stands, supports and color monitor, which may be coupled to a video printer to produce hard copy images(Fig. 2). The scanner is a long-wave, cryogenically cooled system utilizing a mercury cadmium telluride detector with a spectral response of 8-12 mm and a sensitivity of 0.1℃. The scanner is controlled by a dedicated system controller which runs software specifically for thermal image analysis. Room conditions included a draft-free environment(closed door and closed windows with curtains), comfortable temperature control(19-23℃), variable lighting, a swivel chair for patient positioning.

4. Facial imaging

Color thermograms of the face were taken with right and left lateral projections, at 0.1(C sensitivity by 2 well trained dentists. Before the examination, each subject face was cleared of hair (tied back), and TM joint and three trigger points of the face including anterior temporalis and anterior and inferior masseters were wiped with a alcohol sponge then dried with natural air. Ring-like markers were attached in the trigger points to be located in the monitor accurately(Fig. 3).[17]

Each patient was asked to sit quietly, without touching the face, for 20 minutes to allow for facial

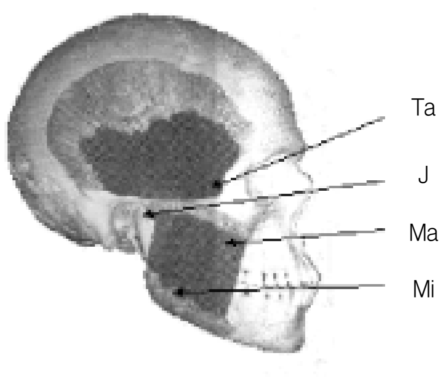

Fig. 1. Location of the areas examined. (J=TMJ; Ta=temporalis anterior; Ma=masseter anterior; Mi=masseter inferior).

Fig. 2. Components of digital infrared thermal imaging systems

Fig. 3. Ring-like markers were attached in the trigger points to be located in the monitor accurately

Fig. 4. The scanner unit was positioned at a distance of 1 m perpendicular to the each side of the face

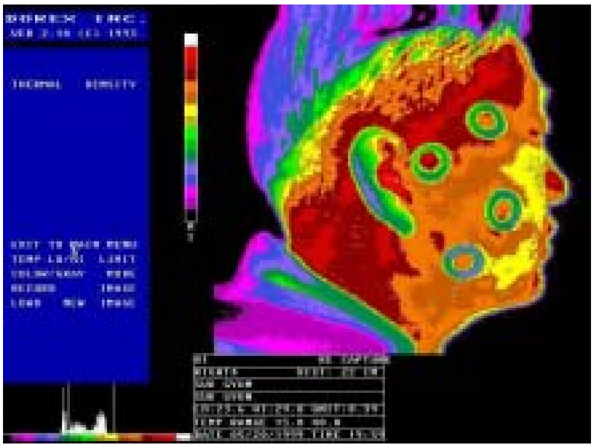

Fig. 5. Facial thermogram displayed on a color monitor

thermal equilibration with ambient room temperature. The scanner unit was positioned at a distance of 1 m perpendicular to the each side of the face, allowing maximum coverage of the area of interest(Fig. 4). Facial thermograms also were displayed on a color video monitor, enabling viewing and computer-aided temperature measurements of selected anatomic zones (Fig. 5) and then all temperatures were measured.

5. Statistical analysis

To determine the statistical significant for the difference of skin temperatures between trigger points in the symptom and symtpom-free side of face, paired t- test was used.

Ⅲ. RESULTS

All means and standard deviations of skin temperatures on the trigger points of symptom and contralateral sides in the patients with acute masticatory pain. The average skin temperatures of pain and contralateral sites in acute muscle disorder were 28.47 to 30.00℃ and 28.47 to 29.85℃ respectively (Table 2). There was significant difference between skin temperatures of pain and contralateral sites totally ($p=0.0075$). Among the trigger points, it can be seen that there were significant differences between skin temperatures of pain and contralateral sites in masseter inferior and joint. The average difference of skin temperature in the trigger points of masseter inferior and joint 0.39 and 0.15℃ respectively.

All means and standard deviations of skin temperatures for the trigger points of patients with chronic masticatory pain are shown in Table 3. In the chronic group, there was no significant difference between skin temperatures of trigger points for pain and contralateral sides. Table 4 shows also that there was no difference between the skin temperatures of trigger points for pain and contralateral sides in joint disorder group.

Table 2. Means and standard deviations of skin temperatures on the trigger points of symptom and contralateral sides in the patients with acute masticatory pain and results of paired t-tests.(℃)

pain	trigger point				p-value
	Ma (n=6)	Mi (n=7)	Ta (n=5)	J (n=6)	
+	28.47±0.68	28.90±0.66	29.20±0.46	30.00±1.74	0.0075
-	28.47±0.84	28.51±0.41	29.24±0.32	29.85±1.72	
	-	0.0488	0.7396	0.0172	

(Ma = masseter anterior, Mi = masseter inferior, Ta = temporalis anterior, J = temporomandibular joint)

Table 3. Means and standard deviations of skin temperatures on the trigger points of symptom and contralateral sides in the patients with chronic masticatory pain and results of paired t-tests.(℃)

pain	trigger points (n=4)	p-value
+	28.72±0.57	0.8544
-	28.73±0.54	

(Ma = masseter anterior, Mi = masseter inferior, Ta = temporalis anterior, J = temporomandibular joint)

Ⅳ. DISCUSSIONS

The skin, one of the largest organs of the body, is equipped with a net work of vessels accompanied by dense nerve fibers. It serves as the body's thermoregulator, controlling blood flow within a few millimeters of the body surface.[32] The system is governed by autonomic nerve impulses generated from the hypothalamus and the brain as a whole. The system is both anatomically and physiologically symmetrical.[28] For this reason, localized, asymmetric temperature changes at the body surface have interested physicians and dentists and this asymmetry was investigated in this study to show the differences between skin temperatures of trigger points in the symptom and contralateral sides for the patients with symptoms seen in the conditions such as acute and chronic masticatory muscle disorders and TM joint disorder.

Factors that affect thermal patterns include surface contour, blood flow to the area, and metabolic activity within the area. Concave surfaces tend to maintain heat more than plane or convex surfaces. Both convection and radiation, two factors responsible for loss of surface which traps air-flow and enables cross-radiation between walls of the concavity. It can be assumed, on the contrary, that the convex surface loses heat easily. It is for these reasons that cheek area was usually cool in this study, although these tissues include enough blood vessel under the skin. Minimizing air currents within the testing room aids in decreasing the convection loss of surface heat.

Table 4. Means and standard deviations of skin temperatures on the trigger points of symptom and contralateral sides in the patients with joint disorders and results of paired t-tests.(℃)

pain	trigger point				p-value
	Ma (n=2)	Mi (n=3)	Ta (n=4)	J (n=9)	
+	28.47±0.68	28.90±0.66	29.20±0.46	30.00±1.74	0.7361
-	28.47±0.84	28.51±0.41	29.24±0.32	29.85±1.72	
	0.5	0.874	0.655	0.7416	

In this study the difference of skin temperature between the trigger points, masseter inferior and joint, having significance are 0.39 and 0.15℃ respectively. Some researchers reported differences of only 0.3℃ and 0.4℃ for left versus right for the TMJ and masseter muscle, respecitively.[22,30] They used thermistor in their studies. Han[17] demonstrated, however, that facial temperature symmetries were within 0.1℃ in his study using digital infrared thermography.[38] The subtle difference of 0.15℃, therefore, is believed to show significant explanation clinically.

Centrally mediated myalgia is a chronic, continuous muscle pain disorder originating predominantly from CNS effects that are felt peripherally in the muscle tissues. The presenting symptoms are similar to those of an inflammatory condition of the muscle tissue, and therefore the disorder is sometimes referred to as myositis. This condition, however, is not characterized by the classic clinical signs associated with inflammation. Chronic centrally mediated myalgia results from a source of nociception found in the muscle tissue that has its origin in the CNS. The most common cause of chronic centrally mediated myalgia is protracted local muscle soreness or myofascial pain.[25]

Skin temperature, a function of superficial perfusion, is largely controlled by the sympathetic vasoconstrictor nerves. Thus, increased sympathetic excitation that is a reflection to nerve root irritation may cause active vasoconstriction, resulting in decreased skin temperature.[5,27] Sato and Schmidt[29] systematically investigated the reflex relationship between the somatic and sympathetic systems, reporting that stimulation of small nociceptive fibers increased the sympathetic firing rate at both the spinal and supraspinal levels. If afferent stimulation is common to both pain perception and temperature control, increased firing from the compressed spinal root would cause both pain and increased sympathetic vasoconstriction, resulting in decreased temperature levels along the dermatomal distribution. It can be seen that there was significant increase of skin temperature in the trigger points of pain side for patients with acute muscle pain in this study. The skin temperature for patients with chronic muscle pain or joint pain, however, was not increased. It can not be neglected, therefore, that these results could be originating predominately from CNS effects, although there are various factors relating to the change of skin temperature.

Infrared thermography offers several advantages as a tool in investigation of acute masticatory muscle disorders. It is a completely different tool that provides information which is not offered by conventional muscle tests. There is no direct invasion. It is non-contact and painless. There is no contaminating radiation. Thermography can therefore be performed as often as desired in follow-up evaluation. Thermography can be useful in evaluating the extent of involvement of acute masticatory muscle disorders and joint inflammation.

V. CONCLUSIONS

Now the use of infrared thermography has been developing in dentistry. This advancement led us to aid precise diagnostic procedure of orofacial pains and temporomandibular disorders. This study compared the skin temperatures of trigger points in the masseter, temporal muscles and TMJ of the symptom and symptom-free sides of faces for the patients with temporomandibular disorders, using a digital infrared thermal imaging system.

In this study we have obtained these result:

1. There was highly significant difference of skin temperatures between pain and contralateral site in the patients with acute masticatory muscle pain ($p<0.0075$).
2. There was no significant difference of skin temperatures between pain and contralateral sites in the patients with chronic masticatory muscle pain.
3. There was no significant difference of skin temperatures between pain and contralateral sites in the patients with internal disc derangement.

In conclusion, infrared thermography appears to have some promise as diagnostic test and treatment assessment for masticatory muscle pain within 6-month, although additional and more extensive studies are needed to be accepted clinically for chronic pain and joint disorders.

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국문초록

턱관절장애환자의 안면 발통점의 피부온도에 대한 연구

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정 덕 진 · 김 기 석

Thermography는 신체 체표면에서 발생되는 온도를 정량화하는 다양한 방법에 대한 일반적인 표현이다. Electrothermography는 의학분야에서 사용이 증가되고 있는 술식이다. 인체를 포함한 모든 물체는 적외선을 방출한다. 그래서, Wien의 법칙에 따르면, 방출되는 최대에너지에서의 주파수는 체온에 의존한다는 것을 알 수 있다. 따라서, 피부 표면에서 방출되는 적외선을 측정하는 것에 의해 온도가 측정될 수 있다. 최근에는, electrothermography가 만성 구강안면동통 환자의 진단에 있어서 새로운 진단 기기로서 각광을 받고 있다.
본 연구에서는 측두하악관절장애의 증상이 있는 교근, 측두근, 그리고 측두하악관절의 발통점의 피부 온도와 증상이 없는 대측의 피부 온도를 디지틀 적외선 체열 촬영으로 비교하고자 하였다.

측두하악관절장애를 주소로 하고 편측성의 구강안면동통을 호소하는 21명의 내원환자를 선택하였다. 디지틀 적외선 체열촬영은 DTI-16-DOREX21(Dorex Inc., U.S.A) 기기를 사용하였다. 발통점 피부에 marker를 부착하고, 좌측과 우측의 color thermogram을 0.1℃ 해상도로 측정하였다. 본 실험에서 측정한 발통점은 masseter inferior, masseter anterior, temporalis anterior 그리고 TMJ이었다. 증상이 있는 부위와 증상이 없는 대측의 피부 온도 차이를 알아보기 위해 paired t-test를 사용하였으며, 실험 결과는 다음과 같다.

1. 급성 근육장애 환자에 있어서는 증상이 있는 부위와 증상이 없는 대측과의 피부온도 차이가 통계학적으로 유의한 차이가 있었다($p<0.0075$).
2. 만성 근육장애 환자에 있어서는 증상이 있는 부위와 증상이 없는 대측과의 피부온도 차이가 통계학적으로 유의한 차이를 볼 수 없었다.
3. 측두하악관절 내장증 환자에 있어서는 증상이 있는 부위와 증상이 없는 대측과의 피부온도 차이가 통계학적으로 유의한 차이를 볼 수 없었다.

결론적으로 적외선 체열촬영은 급성저작근장애의 진단에 있어서 유용한 진단방법의 한가지로 사료되며, 앞으로 임상적으로 더욱더 심화된 연구가 필요할 것으로 사료된다.