FUNCTIONAL INFRARED IMAGING IN THE MYOFASCIAL PAIN

A. Merla*,**, F. Ciuffolo***, G. De Michele**, A. Tangherlini**, M. D'Attilio***, S. Rezza***, F. Festa***, and G.L. Romani*,**

*ITAB – Institute of Advanced Biomedical Technologies – Foundation "Universita' d'Annunzio", Chieti, Italy;
**Clinical Sciences and Bioimaging Dept., University "G. d'Annunzio" of Chieti, Italy
***Section of Orthodontic and Gnathology, Department of Oral Science, University "G. d'Annunzio" of Chieti, Italy;

a.merla@itab.unich.it

Abstract: Literature reports that patients suffering for orofacial pain syndromes exhibit asymmetry in skin temperature distribution, not appreciable in healthy individuals. In the present study, we have investigated whether functional Infrared Imaging (fIRI) allows discriminating patients with myofascial pain syndrome in the head-neck region (MPS) and asymptomatic subjects, through the analysis of the response to a functional test, i.e. the maximal voluntary clenching (MVC). 19 patients and 17 asymptomatic individuals (controls), after having given their informed consent, were enrolled in the study. The functional investigation has documented larger asymmetries in the skin temperature distribution of patients than in controls. Response to MVC has highlighted which regions of interests are mainly involved in the dysfunction: masseter and sternocleidomastoid. Using functional approach in thermal evaluation of myofascial pain syndrome may offer a differentiation criterion between patients and healthy controls, in comparison to the assessment of the at rest thermal asymmetry evaluation.

Introduction

Myofascial pain syndrome (MPS) is a widely diffused disorder which usually affects head-neck region. Its diagnosis is mainly based on the manual identification of physical features of the myofascial so-called trigger points (TP). These are discrete, focal, hyperirritable spots located in a taut band of skeletal muscle, which produce pain feeling both locally and in a referred pattern. Thermal pattern associated with some orofacial painful syndromes have been studied in the earliest researches on the medical thermal imaging [1-4]. These studies have shown that patients with craniofacial pain [2], neurophatic facial pain [3], temporomandibular joint dysfunction [1], and atypical odontalgia [4] exhibited asymmetry in skin temperature distribution not present in controls. Investigation of the thermal response to functional stimulation (like muscular activation) may increase the amount of information obtained by static thermal imaging.

Therefore, in the present study we have used functional Infrared Imaging (fIRI) combined to the response to a functional stimulation, i.e. Maximal Voluntary Clenching (MVC), to evaluate possible existence of specific functional thermal signatures of the MPS in the head-neck region.

Materials and Methods

Subjects: Seventeen patients (mean age, 30 ± 5; age range, 22 -40; M: F, 1: 2.4) consecutively presenting with myofascial pain in the head, neck and shoulder region at the Pain Centre, Section of Orthodontic and Gnathology, Department of Oral Science, University "G. d'Annunzio" of Chieti, Italy, were enrolled. They were compared with a control group including nineteen healthy subjects (mean age, 29 ± 5; age range, 25-36; M: F, 1:1.7) who were selected according to the following criteria: negative history of pain and/or trauma in the interested area (head, neck, and upper-back districts), negative history of the skin problems and blemishes in the same area, negative clinical examination. All participants were asked to avoid applying lotion, make-up or powder on the area, smoking and using drugs for at least four hours before the fIRI test. They were invited to avoid alcohol for 24 hours prior to the measurement as well as hot caffeine drinks.
Protocol: The participants entered the measurement room, removed shirts and clothes, leaving the upper trunk exposed to the fIRI camera. The acclimation time lasted 20 minutes. They stand up-right in front of the camera. Paper markers of known dimension were placed onto the skin surface in correspondence of the anatomical land-marks to permit: (i) post-processing movement correction and images realignment; (ii) identification of the muscle projection onto the skin; (iii) identification of the same regions of interest on all participants; and (iv) quantitative measurements of the average temperature of these regions on the fIRI images.
After having recorded fIRI images at basal conditions, subjects were asked to perform the maximal voluntary

 ISSN: 1727-1983

clenching (MVC) and to maintain it for at least 2 min. Cutaneous temperature distribution and its time evolution for anterior temporal, masseter and sternocleidomastoid regions was studied on the fIRI images taken from the lateral views, while cervical, upper and lower trapezius temperature distribution was obtained from images taken on the back view.

fIRI: was performed using a 14-bit infrared camera (AEG 256 PtSi, AEG Aim GmbH, Heilbronn, Germany), 3-5 µm, 0.02 second time-resolution, 0.1 K temperature sensitivity (NETD), and 0.02 K post processing temperature noise. Emissivity of the skin was estimated as $\epsilon \approx 0.95$. Absolute temperature calibration and removal of drift-shift artefacts in the time response of the sensors were performed by black-body correction. Room temperature were in the 23.0 ± 0.5 °C range and the relative humidity in the 40-50% range, with no forced ventilation. fIRI data were processed by using a dedicated software (Imagepro) [5]. Data were continuously acquired (sampling rate: 1 Hz) starting one minute prior the MVC test (baseline) until 4 minutes after its complete execution. The temperatures of the regions of interest were estimated as mean of temperatures of all pixels in the region.

Data Analysis: For each group, absolute values of differences in temperature between sides (ΔT_s) at each condition (at rest and at the end of MVC), and between conditions (ΔT_c) for each side were calculated. Subsequently, both ΔT_s and ΔT_c were compared between the healthy and myofascial pain groups using the Mann-Whitney non-parametric statistic test for two independent samples. Statistical significance was defined as a two-sided p-value of less than 0.05.

Results

Figure 1 reports an example of head-neck skin temperature distribution changes in MPS patient, as documented by fIRI image series. Table 1 reports the legend for identifying regions of interest in Tables 2 and 3. Table 2 reports ΔTc differences between groups for each side of the studied regions, while Table 3 shows differences between groups in ΔTs at rest and at the end of MVC of the studied regions.

Table 1. Legend of the acronyms used to identify regions of interest

AT	Anterior Temporal
M	Masseter
SCM	Sternocleidomastoid
C	Cervical
UT	Upper Trapezius
LT	Lower Trapezius

MPS patients exhibited larger ΔTc than controls in masseter, sternocleidomastoid, cervical, and upper trapezius muscles ($p<0.05$).

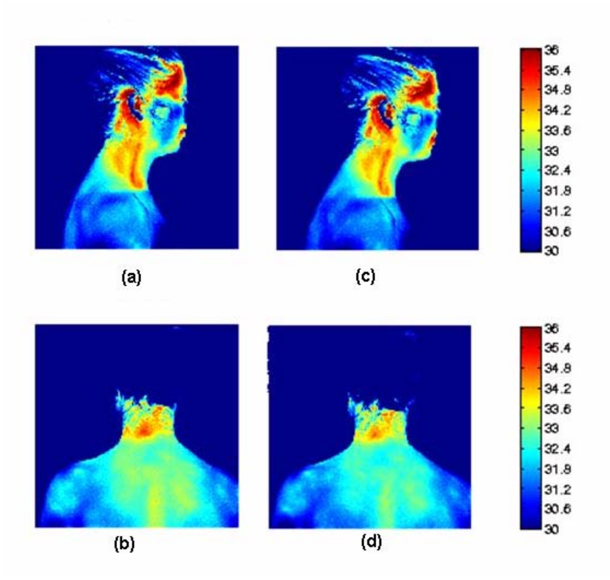

Figure 1: fIRI images of the head, neck and shoulders taken at baseline from the lateral (a) and back (b) views and at the end of the maximal voluntary clenching, lateral (c) and back (d) views, respectively. It is possible to appreciate significant temperature variations across the test performance. Temperature increases in the temporal region and in correspondence of the sternocleidomastoid, while it decreases on the upper trapezius

In contrast, there were no significant differences in anterior temporal and lower trapezius muscles between groups. Therefore, of the six studied sites usually involved in myofascial pain, four responded to the MVC, with temperature variation following the isometric contraction of the masticatory muscles larger in MPS patients than in the controls. The most important differences between groups were found in the masseter and in the sternocleidomastoid, both at rest and after maximal voluntary clenching.

Discussion

Results obtained in the present study suggest that the thermal pattern was different between MPS patients and controls. Patients showed a larger thermal asymmetry and a major temperature deviation due to the maximal voluntary clenching than those observed in the controls. These differences were stronger when considering the temperature changes following the MVC than when evaluating the thermal basal symmetry of the study sites. However, the significant differences between groups were not found in all sites affected by myofascial pain. Of the investigated muscles, only sternocleidomastoid, at rest as well as after MVC, and Masseter, after the MVC, showed a larger asymmetric thermal pattern in patients compared to that observed in healthy subjects.

ISSN: 1727-1983 © 2005 IFMBE

Table 2: Differences between groups in ΔT_c (°C) for each side of the studied regions

	AT		M		SCM		C		UT		LT	
	left	right	left	right	left	right	left	right	left	right	left	right
controls												
min	0	0	0	0	0	0	0	0	0	0	0	0
max	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.5	0.5
25th percentile	0.1	0.1	0.1	0.05	0	0	0	0	0	0	0	0.1
median	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0.1	0.1	0.1	0.1
75th percentile	0.2	0.2	0.2	0.15	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
patients												
min	0	0	0	0	0	0	0	0	0	0	0	0
max	0.6	0.7	0.7	0.7	0.5	0.6	1.1	1.2	1.4	1.4	1.2	1.4
25th percentile	0.1	0	0.1	0.1	0	0.1	0	0	0.1	0.1	0	0
median	0.1	0.1	0.2	0.2	0	0.1	0.2	0.1	0.2	0.2	0.2	0.2
75th percentile	0.2	0.5	0.4	0.3	0.1	0.2	0.2	0.3	0.3	0.3	0.6	0.7
p	NS	NS	<0.05	<0.05	NS	<0.05	<0.05	<0.05	<0.05	<0.05	NS	NS

Table 3: Differences between groups in ΔT_s (°C) at rest and at the end of MVC of the studied regions.

	AT		M		SCM		C		UT		LT	
	rest	MVC	rest	MVC	rest	MVC	rest	MVC	rest	MVC	rest	MVC
controls												
min	0	0	0	0	0	0	0	0	0	0	0	0
max	0.6	0.4	0.5	0.8	0.3	0.4	0.3	0.3	0.3	0.3	0.6	0.6
25th percentile	0.1	0.1	0.05	0.1	0.05	0	0	0	0.1	0.1	0.1	0.05
median	0.2	0.2	0.1	0.3	0.1	0.1	0	0.1	0.1	0.1	0.1	0.1
75th percentile	0.4	0.3	0.3	0.35	0.2	0.2	0.1	0.1	0.2	0.1	0.2	0.2
patients												
min	0	0	0	0	0	0	0	0	0	0	0	0
max	1.1	0.8	1.6	1.4	0.7	0.8	0.4	0.3	0.3	0.3	0.3	0.4
25th percentile	0.2	0.2	0.1	0.1	0.1	0.1	0	0	0.1	0.1	0	0
median	0.3	0.3	0.4	0.4	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
75th percentile	0.6	0.5	0.5	0.5	0.4	0.4	0.2	0.3	0.2	0.2	0.1	0.2
p	NS	NS	<0.05	NS	<0.05	<0.05	NS	NS	NS	NS	NS	NS

In contrast, a major number of muscles manifested a larger temperature deviation, due to the MVC, in patients compared to that found in the controls. This was observed in left and right masseter, right sternocleidomastoid, left and right cervical, and left and right upper trapezius. Scrutinizing the range values of the head (anterior temporal, masseter) and the sternocleidomastoid thermal asymmetries (Table 2), it may be noticed that the maximal values of patients were approximately double than those of the healthy controls, while in the back regions (cervical, upper and lower trapezius) the thermal asymmetry was approximately consistent in both groups. On the contrary, when data are analysed observing the range of the temperature variation due to the maximal voluntary clenching (Table 3), it may be seen that in all patients' spots the maximal values were also approximately double than those of the controls, especially in the cervical, the upper and lower trapezius. From the previous findings, it may be suggested that patients showed a larger asymmetric thermal pattern in the head as well as in the anterior neck muscles, and that the isometric contraction of the masticatory muscles produced in whole muscles of the patients a larger temperature modification in comparison to those of the healthy controls.

The present study provides information on the functional thermal pattern of patients with MPS by using a new generation of infrared imaging device, and these preliminary findings may be helpful to clarify the mechanisms leading to this widespread chronic musculoskeletal painful syndrome.

The knowledge on these mechanisms are still limited, although they may include abnormalities in myofascial tissue, such as ischemia, the accumulation of chemical mediators and sensitization of muscle nociceptors. In the present study, MVC was associated with a larger temperature deviation in patients with MPS in comparison to the controls, even in muscles whose recruitment was not expected during the MVC performance, as the sternocleidomastoid, cervical and upper trapezius. This pattern have been already described by Mongini et al. [2] as the effect of both the anaerobic glycolysis and the change in blood supply, occurring in the muscle tissues of the craniofacial structures following the maximal voluntary clenching effort. The present findings are also in line with those observed in a recent electromyographic study [6], in which a significant increase of the electromyographic activity due to the maximal voluntary clenching was described in neck muscles of the study subjects, suggesting that a muscle co-contraction may occur in this region. With regards to the pathway leading to a regional muscle co-contraction, one may suppose that it could depend on the neurological phenomenon accompanying the orofacial pain syndromes [8-9]. With regards to the findings on the symmetry in thermal pattern, it may be suggested that patients are more asymmetric in the orofacial region than the controls, partially confirming the results of many previous reports [1-4].

Conclusions

Above reported findings suggest that a functional approach in thermal evaluation of the myofascial pain syndrome in the head, neck and shoulder regions offer a better differentiation between patients and healthy controls, in comparison to the assessment of thermal symmetry, and may also provide a major understanding on the peripheral mechanisms associated with this widespread painful syndrome. It can be concluded that in the present study most of the investigated muscles affected by myofascial pain showed a larger thermal response to the maximal voluntary clenching in comparison to the healthy controls. The fIRI promises to be a non-invasive technique for the study of the human peripheral mechanisms leading to the myofascial pain syndrome. Further studies on the diagnostic accuracy are needed to clarify if this tool may effectively improve the diagnostic process in evaluation of this multifaceted chronic painful syndrome.

References

[1] CARAVAN D, GRATT BM. (1995): Electronic Thermography for the assessment of mild to moderate temporomandibular joint dysfunction. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*; **79**: 778-86.

[2] MONGINI F, CASELLI C, MACRÌ V, TETTI C. (1990):' Thermography findings in Cranio-facial pain.' *Headache*; **30**: 497-504.

[3] GRAFF-RADFORD SB, KETELAER MC, GRATT BM, SOLBERG WK. (1995): 'Thermographic assessment of neuropathic facial pain'. *J Orofacial Pain* 1995; **9**: 138-146.

[4] GRATT BM, SICKLES EA, GRAFF-RADFORD SB, SOLBERG WK. (1989):'Electronic thermography in the diagnosis of atypical odontalgia: a pilot study'. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*; **68**: 472-81.

[5] MERLA A (2002):' Imagepro: software for infrared functional imaging.' IFMBE Proceeding; 3: 1612-14.

[6] CIUFFOLO F, MANZOLI L, FERRITTO AL, TECCO S, D'ATTILIO M, FESTA F.(2005):'Surface electromyographic response of the neck muscles to maximal voluntary clenching of the teeth'. *J Oral Rehabil*.; **32**: 79-84

[7] ASHINA M, BENDTSEN L, JENSEN R, SAKAI F, OLESEN J. (2000):' Possible mechanisms of glyceryl-trintrate-induced immediate headache in patients with chronic tension type headache.' *Cephalagia*; **20**: 919-924.

[8] JENSEN R. (1999) : ' Pathophysiological mechanisms of tension-type headache: a review of epidemiological and experimental studies.' *Cephalalgia*; **19**: 622-21.

[9] SESSLE B J. (2005) : ' Peripheral and central mechanisms of orofacial pain and their clinical correlates.' *Minerva Anestesiol* ; **71**: 117-36.