

Functional Infrared Imaging in the Diagnosis of the Myofascial Pain

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Abstract—Functional infrared imaging has been used to study 17 patients, affected by myofascial pain, and 19 healthy subjects during maximal voluntary clenching (MVC). Aim of the study was to attempt to discriminate patients from healthy subjects through the analysis of the skin temperature distribution and its change during the clenching. The pre-stress and the post-stress temperatures were evaluated bilaterally for several regions of interest. We calculated differences in temperature between sides (ΔT_s) at each time (pre and post), and between times (ΔT_t) for each side (left and right). Subsequently, we compared ΔT_s and ΔT_t between the healthy and myofascial pain groups. ΔT_s was significantly higher in sufferers compared to healthy people ($p < 0.05$) for both types of evaluation (by side and by time). ΔT_s was significantly different for masseter and sternocleidomastoid, whereas ΔT_t was higher in almost all sites (masseter, sternocleidomastoid, cervical and upper trapezius). Healthy subjects, undergoing MVC, showed the lowest ΔT value variability, suggesting that temperature remained constant despite the induced physical exercise. Functional Infrared Imaging seems to distinguish healthy subjects from the patients suffering myofascial pain in almost all the investigated sites.

Keywords— clenching, diagnosis, functional infrared imaging, myofascial pain, temporomandibular disorders, thermography.

I. INTRODUCTION

Medical thermography in dental field has been used in the past to attempt to identify specific thermal pattern of the face in patients with neurophatic facial pain, temporomandibular joint dysfunction, craniofacial pain, and atypical odontalgia [1-15]. A study was also performed to evaluate the effectiveness of orthodontic treatments [5].

In general, the studies undertaken in Dentistry have demonstrated the usefulness of thermography to distinguish between healthy people and patients affected by the orofacial syndromes cited above, which are characterized by an asymmetric thermographic pattern while stationary. To our knowledge, only Mongini *et al.* [3] added dynamic condition testing through thermography subjects during maximal voluntary clenching (MVC).

Mongini studied the face and the cervical area, suggesting that the clenching test was useful to increase the amount of information obtained by thermography. Merla *et al.* [13 - 15] showed, in fields other than

Dentistry, that functional infrared imaging (fIR) may provide a highly effective tool to infer information about the presence and the state of some disorders. They used an high-sensitivity infrared cameras, combined with bio-heat modelling, to show how muscular, micro- and/or macro-vascular disorders affect the normal thermal response to a variety of stimuli, such as mechanical work or thermal stress.

The myofascial syndrome is widely diffused in the population, that it does not show specific symptoms and sometimes the underlying factor is difficult to be diagnosed. Aim of this study was to apply the methodology used by Merla *et al.* in patients suffering myofascial pain to evaluate: (i) whether myofascial pain patients, reporting symptoms in the head, orofacial, neck and upper dorsal areas, showed a different thermographic pattern compared to healthy subjects, and (ii) how the maximal voluntary clenching, compared to the "at rest" condition, influenced this pattern

II. METHODOLOGY

Nineteen healthy volunteers (25.5 ± 4.6 yrs; M/F = 1/1.7) without history of TMD and/or myofascial pain, and seventeen patients (30.7 ± 5.3 yrs; M/ F = 1/2.4) affected by myofascial pain in the head, neck and upper dorsal regions participated in the study. All participants gave informed consent, and the study was approved by the institutional review board.

After clinical examination, infrared functional imaging was performed using a 14-bit infrared camera (AEG 256 PtSi, AEG Aim GmbH, Heilbronn, Germany), 3-5 μm , 0.02 second time-resolution, NETD = 0.1 K. Temperatures were black-body calibrated.

Before performing fIR test, participants observed acclimatization in the measurement room for at least 20 minutes, the temperature of which was maintained at (23 ± 0.5) °C and the humidity was 40% to 50%. The participants were then invited to assume a comfortable standing stance, looking straight ahead, during fIR recording.

fIR evaluation consisted of (1) obtaining head, neck and upper dorsal high-resolution thermal images and (2) measuring temperature at rest and after MVC (lasting 1 minute) for (see Fig. 1): the Anterior Temporal (A), the Masseter (B), Sternocleidomastoid (C), Cervical (D), Upper Trapezius (E) and Lower Trapezius (F) muscular bodies.

The pre-stress and the post-stress temperatures were evaluated bilaterally for each muscular body. For each group, we calculated differences in temperature between sides (ΔT_s) at each time (pre and post), and between times (ΔT_t) for each side (left and right). Subsequently, we compared ΔT_s and ΔT_t between the healthy and myofascial pain groups using the Mann-Whitney non-parametric statistic test for two independent samples, since ΔT values did not show a normal distribution. Statistical significance was defined as a two-sided p-value of less than 0.05.

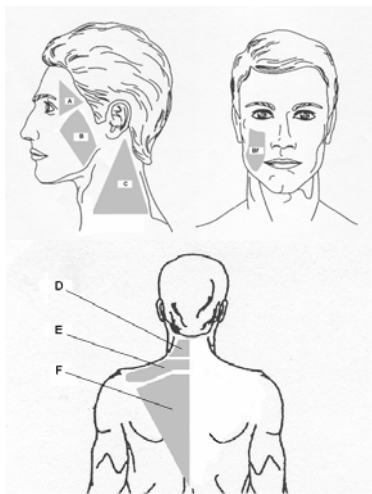


Fig. 1. ROI investigated through fIR.

III. RESULTS

Examples of temperature variations in a typical patient are shown in Fig. 2.

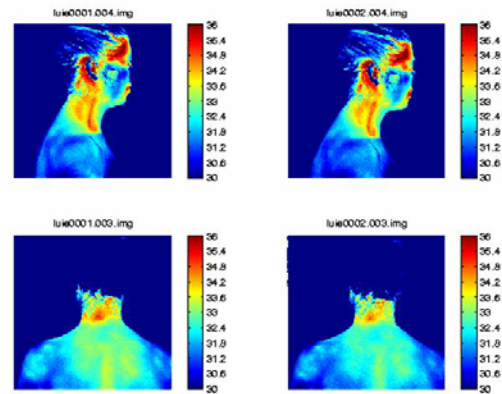
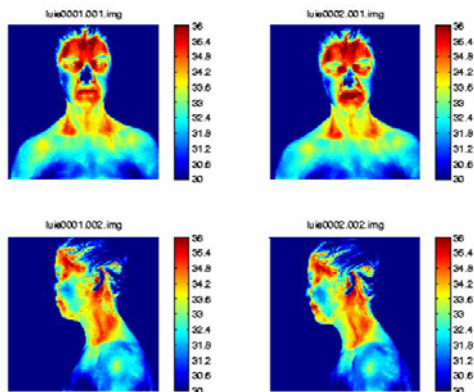


Fig. 2. fIR of the head, orofacial, neck and the upper dorsal regions detected from the frontal, lateral and dorsal views in the pre- (left column) and post- (right column) stress evaluations.

ΔT detected in both healthy subjects and patients suffering myofascial pain are summarized in Fig. 3.

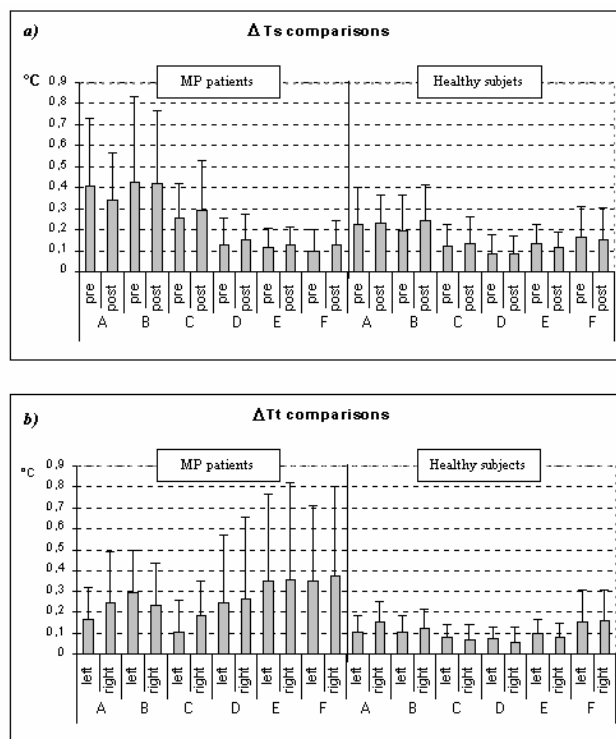


Figure 3. Comparisons between myofascial pain (MP) patients and Healthy subject groups for both ΔT_t (a) and ΔT_s (b) variables. For the legend of sites see figure 1.

Statistical analysis revealed that ΔT was significantly higher in sufferers compared to healthy people ($p < 0.05$) for both types of evaluation (by side and by time). ΔT_s was significantly different for masseter and sternocleidomastoid, whereas ΔT_t was higher in almost

all sites (masseter, sternocleidomastoid, cervical and upper trapezius). In fact, it is clearly shown (figure 3; a, b) that sufferers had higher general temperature variation scores compared to those in the controls, when ΔT was calculated between the conditions (resting and MVC). In contrast, when ΔT was calculated between the left and the right sides greater thermal asymmetry, found in patients, concerned the anterior muscular chains, but not the posterior sites, which showed almost identical patterns to those of the healthy people.

Healthy subjects, undergoing MVC, showed the lowest ΔT value variability, suggesting that temperature remained constant despite the induced physical exercise. On the other hand, controls at rest showed a difference in ΔT range of 0.2 °C, as was the case for sufferers (0.3 °C) for both at rest resting and MVC. Hence, given these latter considerations, it emerges that data variability tends to confirm the lowest ΔT values in healthy subjects undergoing MVC, which showed 0.1 °C difference; therefore, the temperatures of all sites varied minutely.

IV. DISCUSSION

Despite the fact that medical thermography has been largely used for various purposes in different medical fields, both thermographic pattern in myofascial pain patients, reporting symptoms in the head, orofacial, neck and upper dorsal regions, and the effects of maximal voluntary clenching on this pattern, are still unknown.

To our knowledge, this is the first study that provides information on the possible clinical implication of infrared functional imaging on patients with myofascial pain affecting the highest part of the upper half of the body. Our main findings were: (1) sufferers, showed a different thermal pattern characterized by asymmetry in temperature for the facial (masseter) and anterior neck sites (sternocleidomastoid) when compared to healthy subjects; (2) The MVC test, when compared to examination at rest, allowed a greater differentiation between myofascial pain patients and controls, because the greater temperature variations were detected in sufferers in almost all areas (masseter, sternocleidomastoid, cervical, upper trapezius, lower trapezius) in which symptoms had been reported.

The first finding agrees with many previous reports, which have demonstrated that thermal symmetry indicates health. Indeed, this was found in several parts of the body in control subjects, such as in the hands, in the cervical region and upper extremities, in the lower extremities and in the lumbar region. On the contrary, in patients with atypical odontalgia [1], recurrent facial pain or headache [2], and painful TMJ [4], a decidedly asymmetric thermal pattern was found. Hence, in addition to the previously mentioned syndromes, the myofascial pain complaint can be included among those conditions characterized by an

asymmetric thermographic pattern, even if this was not detected in all sites in which the patients had reported a regional chronic muscular pain (head, neck and shoulders), but only in the masseter and sternocleidomastoid muscles.

The infrared functional imaging obtained by the MVC indicated that this diagnostic test can be more sensitive than the static thermographic test, because in these patients there was a correspondence between the sites showing greater temperature variation and the sites affected by myofascial pain. Almost all sites affected by regional chronic pain responded positively to MVC stress. This finding is in accordance with that reported in a study performed by Mongini *et al.* [3], which suggested that isometric contraction of the mandibular elevator muscles resulted in an increase in temperature and spreading of the warmer areas.

The temperature variations which occurred following MVC were probably due to an increase in anaerobic glycolysis in the involved muscles and not to a change in the vascular pattern, even if the presence of abnormal muscle contraction may well influence existing vascular disorders. In this light, the findings reported by other authors on the physiopathology of facial pain and painful associated factors, like masticatory parafunctions, are worth noting and can help to understand this question more fully.

Graff-Radford *et al.* [1] reported that the chronicity of the symptoms could result in impairment of the sympathetic fibers and could lead to a peripheral vasodilatation. In addition, it is well known that chronic regional pain, in particular myofascial pain syndrome, is characterized by trigger points, hyperesthesia, regional tension type ache, stiffness and hyperalgesia, which in the head-neck area are associated with the sensory convergences found in the V-brainstem. With regard to causes related to craniomandibular disorders, there is general agreement that these regional disorders depend on several local factors among which the masticatory parafunctions, especially bruxism, seem to be the most important habits in determining temporomandibular dysfunction.

Given that several fascial linkages are present in the head and neck regions (from the skull to the sub-occipital musculature, to the cervical spine, and to the anterior and posterior cervical muscles; from the facial muscles and their ligaments to the hyoid bone; from hyoid bone to infra-hyoid structures), we could explain the large temperature variation in sufferers through the possible trigger effect during MVC performance, caused by the contracted masticatory muscles (over-used in bruxers) on the other regional muscles (sternocleidomastoid, cervical, upper and lower trapezius). For this reason it is possible that, all muscular sites responded to MVC demonstrating a probable co-contraction in these muscles, which may have induced a significant temperature variation in the

whole region. The whole regional response was more obvious given the general thermal stability detected in healthy people, who, despite having performed the MVC, showed minimal changes in the thermographic pattern with variations of approximately 0.1 °C.

In this light, it emerges that fIR used in this study was able to distinguish healthy subjects from the patients suffering myofascial pain in almost all investigated sites. Therefore, it seems that this diagnostic methodology has a great potential in terms of sensitivity and specificity. Unfortunately, in this preliminary study we are unable to provide information in accuracy because this tool was not compared with other diagnostic tests, considered the gold standard in the muscle evaluation, like surface electromyography. However, with these caveats these preliminary results suggest that fIR may have clinical implications in evaluation of both health and the presence of myofascial pain syndrome in the head-neck region. In other words, the lack of temperature variation could help clinicians to exclude MVC influence on the muscles of this area. In conclusion, we believe that other studies are needed in order to develop and broaden the knowledge of this diagnostic approach estimating the real accuracy and the cost/benefit ratio as compared to the gold standards [12] (e.g. surface electromyography).

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