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ARTIGO DE REVISÃO

Documentação da síndrome dolorosa miofascial por imagem infravermelha

Documentation of myofascial pain syndrome with infrared imaging

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RESUMO

Os pontos-gatilho (PG) miofasciais são encontrados em muitas lesões cervicais com hiperextensão/hiperflexão, discopatias e lesões/desordens por esforço repetitivo. Desde o extremo da simulação, ao frustrante dilema na investigação objetiva da dor crônica, uma das indicações básicas e melhores da comprovação por imagem infravermelha (IR) é a de documentar afecções de tecidos moles, particularmente nos casos em que não são demonstradas por exames radiológicos, eletroneuromiográficos ou laboratoriais. Os autores revisaram a literatura sobre imagem IR na documentação da síndrome dolorosa miofascial. O exame por IR é complemento essencial do diagnóstico clínico mostrando objetivamente PG na forma de pontos aquecidos hiperradiantes. Estas áreas hiperradiantes, correspondem a PG dolorosos anotados no exame clínico. Estes são corroborados pela sensibilidade local e confirmação da dor pelos pacientes. As áreas dolorosas referidas se apresentam termicamente assimétricas com o lado oposto. Os PG latentes, não objetivamente queixados pelos pacientes durante o exame IR, também são descritos sob a forma de pontos hiperradiantes. A presença destes PG latentes pode ser confirmada pela algometria de pressão nestas áreas. Após infiltração/agulhamento há alteração do perfil térmico cutâneo demonstrando resposta neurovegetativa simpática imediata. As alterações de imagem IR se constituem, assim, em importante recurso objetivo na demonstração de PG miofasciais, correlatos com as queixas objetivas do paciente. A documentação dos PG por imagem IR é útil no direcionamento para causa da dor, orientação do tratamento adequado, assim como avaliação de sua resposta.

PALAVRAS-CHAVE

síndromes da dor miofascial, termografia, diagnóstico por imagem

ABSTRACT

The myofascial trigger points (TP) are involved as much pathologies of hyperextension/hyperflexion cervical injuries, disc injuries, and overuse injuries. From the extreme of malingerer to the frustrating dilemma of intractable chronic myofascial pain, the documentation of this alteration is in the majority of the cases subjective and a dilemma. One of the basic indications and clinical uses of infrared (IR) imaging is documentation of soft tissue pathology, particularly in conditions which cannot be demonstrated on radiologic tests, electroneuromyography or laboratory workup. The authors review the literature regarding IR imaging in the documentation of myofascial pain syndrome. The IR imaging is a diagnostic test which objectively documents TP in the form of hyperradiant hot spots. These hyperradiant spots corresponding to areas of pain usually represent active TP in clinical examination. They can be corroborated by local tenderness in the region, thus confirming the patient's complaint. The areas of pain are presented as thermal asymmetry between corresponding areas of opposite sides of the body. Latent TP, not subject to patient complaints at the time of IR imaging examination, are detected in the form of hyperradiant spots. The presence of these latent TP can be documented by abnormal pressure threshold measurement in these areas. There was an alteration of the skin thermal profile after TP local anesthesia/dry needling demonstrating an immediate neurovegetative sympathetic response. The IR imaging findings represent an objective mean to document TP, thus corroborating with the

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subjective patient's complaints. The documentation of TP by IR imaging is important to introduce the most adequate treatment directed the pain cause as well as to evaluate its response.

KEYWORDS
myofascial pain syndromes, thermography, diagnostic imaging

INTRODUCTION

The differential diagnosis of chronic pains related to soft tissues is a challenge. From the extreme of pain malingering to the frustrating dilemma of myofascial chronic pain, the documentation has been based, in most cases, on clinical experience. The myofascial pain syndrome (MPS) is one of the most common causes of musculoskeletal pain. It affects muscles, connective tissues and fasciae, mainly in the cervical region, scapular and lumbar girdle. The pain and disability caused by the MPS can be rather significant[1,2,3].

Frequently, patients with MPS use several types of medication and can present pain recurrence after a badly planned treatment. An adequate therapeutic program must obey an interdisciplinary model to control the pain and promote the patient's physical, psychological and social rehabilitation. Basically, the treatment of MPS consists in the inactivation of trigger points (TP) and the interruption of the pain-spasm-pain vicious cycle. However, the correct diagnosis of locating all implicated TP is mandatory, as the perpetuation of these points, if they go untreated, can cause disease recidivism and be the cause of several medical return visits[4].

The diagnosis of MPS depends exclusively on the patient's history and physical examination. The MPS is a regional painful muscular condition characterized by the occurrence of taut muscular bands, a ropey thickening of the muscle tissue, where intensely painful areas can be identified, i.e., the TP; the latter, when stimulated by digital palpation, generate pain either locally or referred pain[4]. Nevertheless, due to the patients' subjectivity when reporting their symptoms, sometimes not all points are identified at the clinical evaluation. Another factor is that the examiners must be trained and experienced in the assessment of these patients, as even when they are, the inter-examiner reliability varies from 35 to 74%, which makes it mandatory to associate methods to increase the clinical sensitivity[5,6,7,8].

The non-identification of the MPS is also responsible for many misdiagnoses and therapeutic failures of chronic painful symptoms, loss of productivity and biopsychosocial disability. Many patients with MPS are stigmatized as neurotic or presenting psychosomatic abnormalities[9,10].

The usefulness of the infrared (IR) imaging has been well documented in the literature as a diagnostic method for the detection of TG in the MPS[11-20,21].

The thermograms can be obtained by IR radiometry or liquid-crystal films. The changes in the skin temperature over a large body area can be obtained quickly by computer-assisted IR radiometry (electronic thermography) at distance. This technique can demonstrate the skin neurovegetative somato-somatic reflex phenomena characteristic of myofascial TP. The ordinary liquid-crystal plaques (contact thermography) have limitations that make the interpretation more difficult and inaccurate, and consequently, their use have been discontinued.

INFRARED (IR) IMAGING

IR imaging is a non-contact, painless and non-contrast diagnostic procedure, which determines the skin microcirculatory activity (perfusion). All bodies emit infrareds when the temperature is above absolute zero (–273º C). The human body emits infrared rays within the range of 0.75 to 15 μm. These rays are invisible to the naked eye and indicate the degree of molecular agitation. The shorter the wavelength, the higher its energy is. The IR imaging camera converts the energy irradiated by a body surface into a visible image.

The IR camera consists of an IR detector, an electro-optical scanning system and electronic controls. By oscillating mirrors and prisms, it creates an image of 30,000 to 64,000 small points in the visual field; hence, when the electronic signal is shown on the cathode-ray screen, the resulting scanned image contains 30,000 to 64,000 precise points of temperature. On average, with a 50-cm distance between the camera and the object, each point corresponds to an area of 1 mm^2.

One of the basic and clinical use indications of the IR imaging is the documentation of soft tissue diseases, particularly those that cannot be demonstrated by laboratory, radiological or electroneuromyographic assessment, with myofascial TG being a frequent condition.

This IR technique measures the superficial skin temperature up to a depth of 6 mm. The changes in superficial temperature correspond to alterations in the skin (dermis) circulation and not below it. The endogenous cause of these alterations is usually the activity of the neurovegetative sympathetic nervous system.

The alterations in the IR imaging of the skin temperature are compatible to those obtained by electric resistance variation or sweat production (Minor's test), although the IR imaging is better than the other two methods, in terms of convenience as well as spatial and temporal resolution.

INFRARED ASSESSMENT

The IR imaging system, in the evaluation of the MPS, consists of a thermal sensor, computer and monitor used to detect the differences in IR radiation as differences in temperature and its response to treatment of myofascial TP.

The IR images must be obtained before the palpation of the painful points or the pressure algometry.

The patients are advised not to expose themselves excessively to the sun (sunburn), to avoid the use of facial or body lotions, alcoholic or caffeinated beverages, exercises, physical therapy and strenuous physical exercises on the day of the examination. They must wait for 15 minutes, with the body region of interest (ROI) undressed, in a room with a constant temperature of 20º C and no air currents before the IR images can be obtained.

The images are obtained from an average distance of 1.5 m with the patient in the orthostatic position. The thermal activity of an area of 1 cm^2 in the central part of the TP and of a symmetrical point in the opposite side of the body is registered in Celsius degrees. The intensity, size, shape, distribution and margins are also evalauted[22]. A difference of at least 0.5º C between the myofascial TG and its symmetrical point is considered thermal asymmetry and a diagnostic criterion.

TRIGGER POINTS

The diagnosis of MPS can be complex. IR imaging is a useful diagnostic method to confirm the presence of this syndrome[23,24,25,26]. The myofascial pain can be either local, near the TP, or can produce a referred pain phenomenon at the extremity, which mimics radicular symptoms of neurogenic origin.

Travell and Simons[4] published an extensive study mapping the TP and their regions of referred pain. The TP are generally areas of hyper-irritability with a localized taut muscular band. The TP are painful on palpation and the digital compression of an active TP can evoke pain and paresthesia in its region of reference. When stimulated, a TP will produce a response of local contraction in the muscle.

The myofascial TP stimulate the neurovegetative sympathetic nervous system, causing autonomic symptoms. The autonomic function disorders caused by the TP include: abnormal sudoresis, watery eyes, persistent rhinorrhea, excessive salivation and piloerectile activity.

The reported proprioceptive disorders caused by the TP include: disequilibrium, dizziness, tinnitus and distorted perception of the weight of small objects.

Additionally, there are referred autonomic phenomena: vasoconstriction (blanching), cooling, sudoresis, pilomotor response, ptosis and/or hypersecretion that occurs in a region distant from the TP, causing these phenomena. The phenomenon usually appears in the same area of the TP referred pain.

INFRARED FINDINGS

IR imaging is the first diagnostic test that objectively documents the TP as hyper-radiation hot spots[27]. A typical image is a localized discoid hyper-radiation area, generally 5-10 mm in diameter, located directly on the symptomatic TP[13,14,21,23,27] (Figure 1).

It is a consensus among the best therapists that the homologous right and left sides of the body are similar (symmetrical) with a difference of just a few decimals of degrees (± 0.3º C)[28-30].

The TP, as previously mentioned, have a typical discoid appearance and are generally 1º C more elevated when compared to the opposite side or surrounding region (Figures 2 e 3).

Five studies have reported a hyper-radiation region on TP (a total of 170 TP)[16,23-26]; no study has reported a finding of hypo-radiation (subcooling).

In a simplified manner, there are three theoretical scientific reasons for the hyper-radiation near the TP.

In the presence of muscular spasm, the IR imaging corresponds approximately to the anatomical disposition of the affected muscular bands[22,31] (Figure 3).

The increase of muscular activity can cause changes in the IR imaging. The radiation profile around a myofascial TP reflects, to some extent, the metabolic activity of the affected muscle[23]. The increased metabolism due to the continuous muscular contraction will produce energy in the form of heat, which will be taken to the skin by the microcirculation. This venous drainage transports vertically heated blood close to the body surface, where most of the heat is lost to the environment.

The second is by a redirecting mechanism. The skin hyper-radiation would be caused by a restriction of blood flow by the spastic muscle. The central blood temperature is redirected in collateral microvessels in the skin around the myofascial TP[4,23].

However, Fisher and Chang[23], using a needle with a thermal sensor in the extremity verified that, in 14 patients with TP in the gluteus medium, the temperature between a TP and the contralateral muscle was the same, as the needle was introduced into the muscle (± 5 cm). The only statistically significant difference was the skin surface, which was warmer in the TP projection area (1.15±0.38ºC *versus* 0.05±0.48ºC, $p<0.001$), measured by IR imaging. The authors concluded that the hyper-radiation on the TG could not be attributed to conduction, but to a somatocutaneous medullary reflex response of vasodilation due to the local nociceptive impulses (ischemia, contracture and others).

The IR sensors are developed to detect and measure patterns of skin hyper-radiation that the myofascial TP produce. Further studies carried out by Fischer *et al*[13,14,,23,24,27] using IR imaging for the diagnosis and follow-up of TP, correlated pressure algometry with IR imaging, finding a statistically significant correlation[24]. Subsequently, other authors published similar results as case reports[11,12,14-16,19,21].

With the IR imagining, it is possible to document autonomic vasomotor alterations of the TP. Non-stimulated TP tend to reflect spontaneous autonomic skin effects that induce hyper-radiation in a limited area of the skin on the projection of the TP, whereas the mechanical stimulation of the TP, which causes more pain, generally induce stimulus-dependent reflex hypo-radiation[26] (Figure 4).

This phenomenon of reflex hypo-radiation is another discriminating criterion in the diagnosis of the TP, and it is even more important than the hyper-radiation on the TP. Studies have indicated that when the referred pain is produced by the compression of a TP, the reference zone usually becomes hypo-radiating. Travell and Simons[4] examined a patient that clearly demonstrated such situation. However, the referred pain region of the TP can also show hyper-radiation at the autonomic referred zone.

IR imaging is extremely important when the patient complains of referred chronic pain in the extremities and is misdiagnosed as having radiculopathy. The IR imaging will indicate a "myofascial pattern" different from the "dermatoform pattern", which is typically neurogenic/radicular, seen in radiculopathy cases, in addition

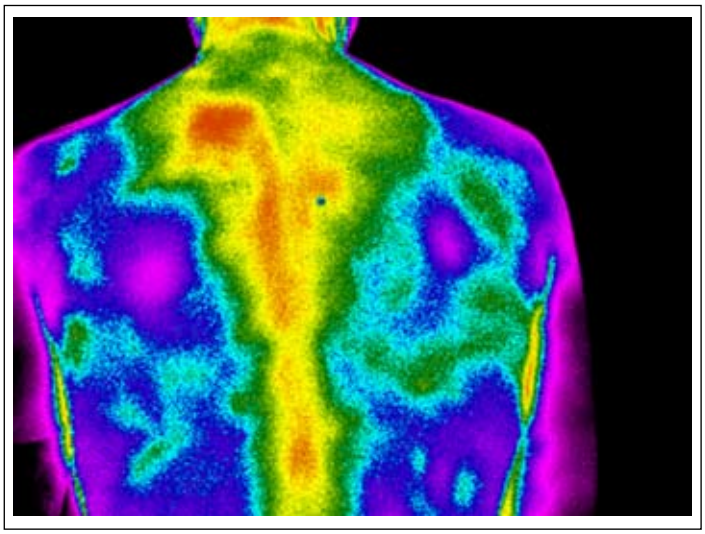

Figure 1
Hyper-radiation on the TP of the levator scapula.

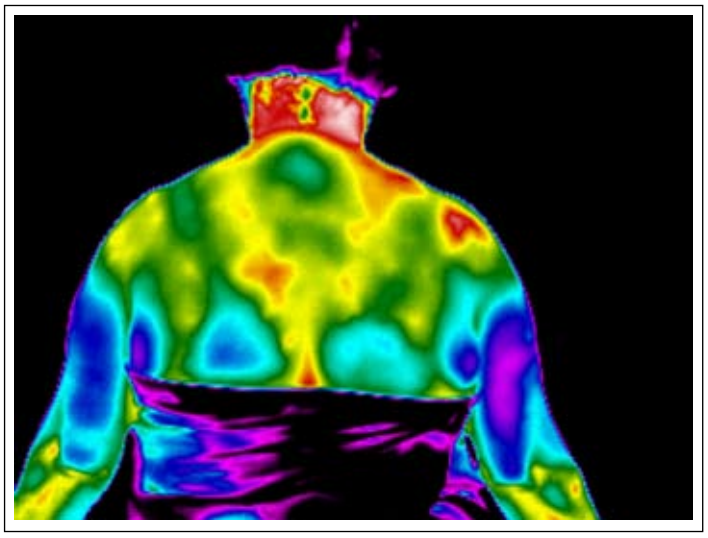

Figure 3
Hyper-radiation on TP of the right upper trapezius muscle, associated to right supra-spinal tendinopathy.

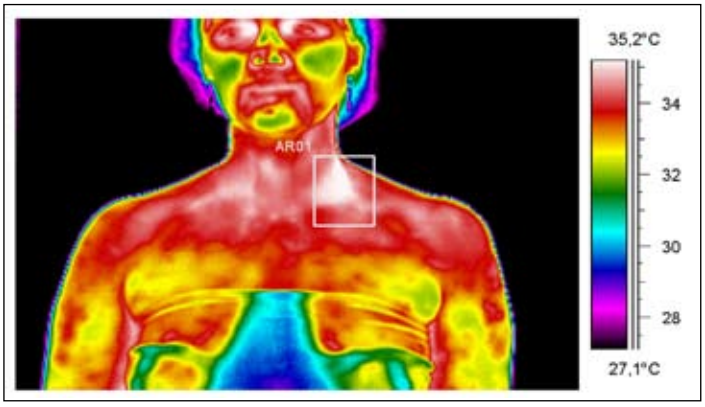

Figure 2
Focal hyper-radiation on myofascial TP of the left scalene muscle.

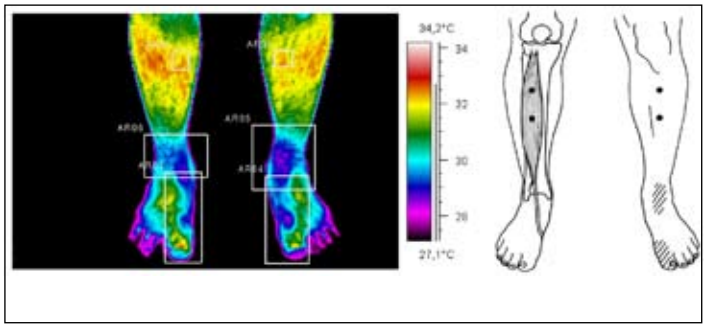

Figure 4
Hyper-radiation on TP of the bilateral anterior tibial muscle with hyper-radiation in the reported painful region according to the schematic representation to the left.

to those that can occur by the painful pressure applied to a painful joint dysfunction, bursitis or enthesopathy, also "inflammatory patterns".

Diakow[26] carried out a study to observe whether the active TP exhibited a hyper-radiation region extending along the referred pain area when compared to a latent TP, with a negative presupposition. Additionally, the author analyzed a subgroup of 25 patients with joint dysfunction that could be the cause of the hyper-radiation in the same area of referred pain of the TP. When this subgroup was suppressed, the distinction between the active TP and the latent ones increased. Of the remaining 104 patients, there was an increase in specificity of 70% to 82%, sensitivity remained constant at 74% and there was an increase of Cohen's Kappa from 0.44 to 0.54.

These results show that the joint dysfunction can be the additional cause of hyper-radiating points, which is in agreement with the studies by Korr *et al*[32] on facilitated segments.

However, with the increased resolution of IR imaging, it is easier to distinguish myofascial pattern hyper-radiations from those with an inflammatory pattern, characteristic of joint hyper-radiations[32] (Figure 3).

Kruse and Christiansen[25] evaluated the correlation between the IR hyper-radiating area and the TP located by the clinical examiner. They carried out a well-controlled study of the thermal changes in the referred pain region of the TP in response to pressure on the TP in the trapezius muscle. The criteria used for the diagnosis of TP were those established by Travell and Simons[4].

IR images were obtained bilaterally from five established places in the UULL of 11 volunteer students with symptomatic TP in the trapezius muscle and from 11 asymptomatic controls. Initially, the images were used to find the thermally active TP confirmed by palpation. The algometry of the TP and the corresponding contralateral sides was carried out. Pressure was applied to the TP until

the individual felt the referred pain and it was then kept for 1 minute while the thermograms were recorded every 15 seconds. Initially, there was an increase in the temperature of the TP region TP, when compared to the control side. The referred pain region initially showed a small increase; however, with the continuous pressure on the TP, the area of the thermal response (toward the referred pain) showed a statistically significant reduction of temperature, whereas the control sides showed a non-statistically significant increase of temperature. It is also noteworthy the fact that the area of the visible thermal response, i.e., the one that was objectively evaluated, was more extensive than that of the referred pain reported by the patient, which is evaluated subjectively. The value of the algometry of pressure for the TP was significantly lower ($p<0.0001$) than of the control site, reflecting a higher sensitivity of the IR method. However, this study did not consider the hypothesis that active TP were not capable of being visualized at IR imaging.

Fischer and Chang[23] tried to examine the hyper-radiation points of the gluteal region of 14 patients with lumbar pain. The hyper-radiating points correlated with the painful points in 13 muscles and 1 ligament. The lower pressure points at the algometry correlated significantly with the hyper-radiating points when compared to the contralateral opposite side ($p<0.01$). The hyper-radiation points apparently are painful points, but the study did not distinguish whether these painful points were due to myofascial TP or fibromyalgic painful points or other causes.

According to Gerwin[33], 50% of the patients with fibromyalgia can present associated TP. However, Scudds *et al*[34], used IR imaging to examine the back of 49 patients with fibromyalgia and 19 with myofascial pain, at rest, together with the algometry study of the referred pain. They observed that the mean skin temperature of the patients with myofascial pain was 0.65% ºC higher than that of patients with fibromyalgia. This study suggests that patients selected primarily by myofascial TP are more prone to exhibit hyper-radiation than patients with fibromyalgia.

Apparently, the active spot responsible for the TP causes not only referred pain, but can also refer local hyper-radiation. Biase *et al*[35] using IR imaging, evaluated 156 patients with fibromyalgia and found an unspecific hyperthermal pattern on the painful muscular areas, indicating the method as an adjunct in diagnosis attainment as well as in the patients' follow-up.

In any study by IR imaging, it is important and necessary that the TP are identified by adequate diagnostic criteria and differentiated from painful points found in patients with fibromyalgia. When symptomatic TP resolve clinically and the pain disappears, the imaging findings usually go back to normal[36]. For the IR imaging findings to be considered significant, they must be correlated with the clinical assessment.

Brioschi *et al*[37] evaluated 304 patients with chronic MPS with IR imaging before and after anesthetic infiltration or dry needling. The hot spots corresponded to painful areas that represented active TP at the clinical examination. They could be corroborated by local sensitivity and the confirmation of the patients' complaints. The referred pain areas showed to be thermally asymmetric with the corresponding side. The latent TP, which were not objective complaints of the patients during the IR assessment, were also detected as hot spots. The presence of these latent TP can be confirmed by the algometry in these areas. After infiltration/needling there was alteration of the thermal profile, showing an immediate sympathetic neurovegetative response.

The IR findings represented an objective means of documenting myofascial TP, corroborating with the patients' objective complaints. The identification of the TP by IR imaging is important to institute the most adequate treatment directed at the cause of pain, as well as evaluate the pain response.

In many cases, the IR imaging can be the only finding of a complementary examination.

Menachem, Kaplan and Dekel[38] found a hyper-radiation image corresponding to the TP and local crepitation as the only positive findings in 60% of the patients with scapular girdle pain due to levator scapula syndrome. A total of 75% of them experienced pain relief after being treated with local injections of steroids directed by the IR imaging.

Sucher[39] described four cases of thoracic outlet syndrome with a primarily myofascial etiology, involving the scalene and pectoralis minor muscles, in whom the IR imaging was the only finding of the complementary examination in addition to the clinical assessment.

The IR imaging meets the scientific criteria adopted for the complementary diagnostic validation, as previously published in the literature. Several researchers have presented the method as a test with high reproducibility, sensitivity and specificity, as well as having a high predictive value and inter-examiner reliability[24,28-40].

Only two studies did not attain good results with IR imaging in MPS. Swerdlow and Dieter[41] examined 165 patients that presented soft tissue disorders and found TP in the upper, middle and lower trapezius muscle in 139 of them. Using Fisher's[24] criteria of IR assessment, they found a 40% incidence of false-positive and 20% of false-negative cases. The lack of experience of the authors regarding the method and the use of equipment with a low imaging resolution might have contributed to these results.

Radhakrishna and Burnham[42] evaluated 32 points of the upper and middle trapezius muscle in 16 patients with myofascial pain in the scapular girdle. The authors did not find any significant association between the temperature of the painful points and pain measured by algometry and rejected the IR method. However, it is worth mentioning that the authors did not clinically differentiate active TP from latent ones and included two conditions with different etiopathologies, i.e., fibromyalgia and MPS, in the same group. Additionally, they used punctual IR thermometry and not IR imaging.

The myofascial TP can be involved in many conditions such as cervical injuries with hyperextension/hyperflexion, disc injuries, temporomandibular joint (TMJ) disorders and repetitive strain injuries (RSI) or lesions. The piriformis or gluteus minimus TP, for instance, can be wrongly interpreted as sciatic radiculopathy, if they are not confirmed by a positive IR imaging examination and negative MRI. The IR imaging is also useful in the TMJ disorders, as muscles such as the masseter, temporal and pterygoid usually

become hyper-irritable with taut bands and TP[42-45].

The IR imaging can be used not only as a diagnostic but also as follow-up method.

Wang, Long and Zhu[46] described the use of the IR imaging in the identification of the "Ah Schi" points (TP) in the TMJ region, as well as in the acupuncture treatment follow-up.

In summary, studies indicate that a hyper-radiating point at the IR thermogram is not enough to identify a TP below it. Similar thermal changes can be found in radiculopathies, joint dysfunctions, enthesopathies or localized subcutaneous inflammatory processes. Thus, it is important to carry out a clinical evaluation concomitantly with the examination and the latter must be performed by an experienced physician who is skilled in Clinical Thermology.

The IR examination is a type of technology that was abandoned by the medical community in the 80's, due to the fact that it was performed with precarious instruments and in its majority carried out with liquid-crystal plaques; currently, the extraordinary improvement of high-resolution imaging cameras is visible.

The perspectives of IR imaging as a new method within the spectrum of examinations that can be used in a patient with myofascial chronic pain are very good, especially to document non-specific conditions.

The method is a complementary to the clinical examination and, in this case, cannot be performed by a technician for posterior assessment, as in the case of anatomical assessments (x-rays, tomography and MRI), but it must be carried out by a skilled physician. It is also important to perform it in a qualified service, using qualified equipment that can meet the established specifications[47].

There are yet many questions to be answered on IR imaging and its association with TP. Although many acupuncturists use punctual electrical resistance components to identify the most appropriate sites for needle insertion and inactivate the TP (or to treat a painful acupuncture point), it would be interesting to carry out a blind study, evaluating the region of the hyper-radiating point with a low-resistance point, in order to determine for how long this low-resistance point is corresponding with the hyper-radiating one and whether there is a TP (active or latent) below it.

Currently, the presence of the TP is determined by adequate diagnostic criteria applied by trained and skilled examiners, despite the low inter-examiner reliability[5-8]. Although several studies have demonstrated that a characteristic dysfunction of the TP is modulated by sympathetic activity[48-50], further studies on the effects of the TP on the sympathetic control of skin perfusion will increase the knowledge on the functional association between myofascial TP and the neurovegetative nervous system, increasing the use of IR imaging in its assessment.

The IR imaging examination has high sensitivity, and it increases directly with the examiner's experience. However, the sensitivity and specificity of the IR imaging are of little interest due to its assumed importance when used under the adequate conditions.

The request for IR imaging can be considered in cases of myofascial pain, especially when:

• One wants to objectively document all TP for the diagnosis and treatment follow-up.

• The initial diagnostic hypothesis is of a non-specific condition, i.e., there is no objective substrate that can be demonstrated by anatomical examinations.

• The patient presents signs and symptoms of a non-specific condition.

• The objective is to rule out a non-specific condition (simulation).

• The findings described in the traditional examinations are not compatible with the findings of the clinical history and clinical examination.

• The alterations found do not explain the patient's entire clinical picture.

• When other complementary examinations did not detect alterations.

• When there are no abnormalities at the clinical examination.

• When an expert opinion is required at forensic examinations.

FINAL CONSIDERATIONS

IR imaging is a useful, non-invasive examination for the diagnosis and more objective follow-up of myofascial TP. As the myofascial pain syndromes are part of the daily musculoskeletal practice, the IR imaging is very valuable in clinical practice and can promote a faster and more effective rehabilitation of the patient with MPS.

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