# Can infrared thermography replace other methods of assessing orofacial pain intensity? Systematic review

*A termografia infravermelha pode substituir outros métodos de avaliação da intensidade da dor orofacial? Revisão sistemática*

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## ABSTRACT

**BACKGROUND AND OBJECTIVES**: Measuring pain is complex due to its various components, including the subjective aspect. Establishing an effective and safe method for assessing orofacial pain (OFP) is extremely important. The objective of this study was to conduct a systematic review to verify whether Infrared Thermography (IT) can be used as a substitute for other methods of evaluating the intensity of neuropathic or musculoskeletal OFP.

**CONTENTS**: Five databases were searched: Pubmed, Scielo, Web of Science, Scopus, and Cochrane. The PECO question was used to guide the definition of eligibility criteria used to select the articles. The risk of bias was analyzed using the Joanna Briggs scale. Five studies met the eligibility criteria. Of the five eligible studies, four reported an association between orofacial pain intensity and temperature. Of these, one article showed that patients with temporomandibular disorders (TMD) and pain showed an increase in temperature when compared with individuals without pain. The other three articles showed a decrease in temperature with increasing pain intensity. In only one study pain intensity was not significantly associated with temperature.

**CONCLUSION**: IT does not replace other pain intensity assessment methods, but it is an important ally for complementing diagnostic procedures. Additional investigations are necessary to find a standardized method for obtaining and analyzing orofacial infrared images.

**Keywords**: Facial pain, Systematic review, Thermography.

## RESUMO

**JUSTIFICATIVA E OBJETIVOS**: A mensuração da dor é complexa devido aos seus vários componentes, incluindo o aspecto subjetivo. É extremamente importante estabelecer um método eficaz e seguro para avaliar a dor orofacial (DOF). O objetivo deste estudo foi realizar uma revisão sistemática para verificar se a termografia infravermelha (TI) pode ser usada como substituta de outros métodos de avaliação da intensidade da DOF neuropática ou musculoesquelética.

**CONTEÚDO:** Foram pesquisados cinco bancos de dados: Pubmed, Scielo, *Web of Science*, Scopus e Cochrane. A questão PECO foi usada para orientar a definição dos critérios de elegibilidade usados para selecionar os artigos. O risco de viés foi analisado usando a escala Joanna Briggs. Cinco estudos atenderam aos critérios de elegibilidade. Dos cinco estudos elegíveis, quatro relataram uma associação entre a intensidade da dor orofacial e a temperatura. Desses, um artigo mostrou que os pacientes com distúrbios temporomandibulares (DTM) e dor apresentaram um aumento na temperatura quando comparados com indivíduos sem dor. Os outros três artigos mostraram uma diminuição da temperatura com o aumento da intensidade da dor. Em apenas um estudo a intensidade da dor não foi significativamente associada à temperatura.

**CONCLUSÃO:** A TI não substitui outros métodos de avaliação da intensidade da dor, mas é um importante aliado para complementar os procedimentos diagnósticos. São necessárias investigações adicionais para encontrar um método padronizado de obtenção e análise de imagens infravermelhas orofaciais.

**Descritores**: Dor facial, Revisão sistemática, Termografia.

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**HIGHLIGHTS**

- This review provides an updated analysis of the relationship between the intensity of neuropathic or musculoskeletal orofacial pain and temperature.
- Infrared thermography does not replace other methods of assessing pain intensity, but it serves as a valuable complement to diagnostic procedures.
- Further investigations are needed to establish a standardized method for obtaining and analyzing orofacial infrared images.

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## INTRODUCTION

Orofacial pain (OFP) is a condition related to the soft and hard tissues of the head, face, and neck, potentially caused by pulpal and periodontal, vascular, glandular, muscular, and bone changes, involvement of the sinuses and joint structures[1]. Risk factors for OFP include having widespread chronic pain, being female, age and psychological factors[2].

It is essential to obtain as much information as possible about the patient's pain experiences, as they are individual and subjective. It is also necessary to consider the patients' expectations regarding treatment, their health in general and the impact caused by pain on their quality of life[3]. This information must be obtained by means of the patient's detailed report on history of pain, appropriate clinical assessment, including a comprehensive physical examination of the dental, and head and neck region, palpation, visual analogue scale (VAS) or numeric rating scale (NRS), DC/TMD (Diagnostic Criteria for Temporomandibular Disorders), RDC/TMD (Research Diagnostic Criteria for Temporomandibular Disorders), Fonseca Anamnestic Index (FAI) and complementary radiographic exams[4-6]. Nevertheless, they are methods with implications and limitations with regard to their application.

For the VAS and the NRS, it is essential for the patient to be fully conscious and cooperative. The observation of non-specific clinical parameters or signs, in addition to the subjective assessment of vital parameters or changes in these, such as tear flow, sweating, defensive movements and the patient's facial expressions, can be used to assess pain. These assessments demand extensive clinical experience and close observation by the dentist[4].

For RDC/TMD and DC/TMD, the operator requires extensive training and mastery of the evaluation method[7]. For complementary imaging exams, including magnetic resonance imaging (MRI), computed tomography (CT) and cone beam computed tomography (CBCT), there is a high cost involved, direct exposure of the patient to ionizing radiation in tomographic exams, in addition to lack of information in the analysis of physiological functional aspects, such as microcirculation and the autonomic nervous system of the region analyzed[8].

Infrared Thermography (IT) has gained space as an alternative diagnostic method. IT is a painless, non-invasive, non-ionizing and low-cost method that reveals the distribution of body temperature and detects functional, nervous, and vascular changes by means of real-time photographic imaging, based on the capture and transmission of infrared radiation emanating from the human skin[9]. Despite the advantages, temperature values are directly affected by environmental and patient conditions, which must be carefully controlled to avoid obtaining inaccurate body temperature data by IT[10]. It is also important to note that the thermographic imaging is not a "pain picture", but rather an indirect tool for detecting changes in cutaneous vascular supply, which typically result in variations in skin temperature[11]. IT is a physiological test, and like any physiological test, normal values should be established. Several authors have demonstrated that normal individuals exhibit thermal symmetry, meaning corresponding parts on opposite sides of the body show extremely small temperature differences[11,12]. Therefore, any altered pattern should be correlated with other clinical findings or established diagnostic tests[11].

Thermographic patterns may vary in different painful conditions[11,13]. For example, in chronic reflex sympathetic dystrophy a diffuse pattern of hypothermia is usually seen. In myofascial syndromes, trigger areas generally have an elevated temperature[11]. The literature also diverges regarding the behavior of temperature in the masticatory muscles in cases of OFP. Some studies have indicated an increase in muscle temperature in individuals with TMD compared to a control group[14,15], while others have reported a decrease in temperature[16,17].

It is known that measuring pain is a complex task due to the different components involved, including the subjective aspect. Establishing an effective and safe assessment method for OFP is of utmost importance. Furthermore, knowing more about the relationship between pain intensity and temperature is essential to establish a more assertive treatment approach. Therefore, the aim of this systematic review was to evaluate IT as a possible diagnostic tool to replace other methods for assessing the intensity of OFP.

## CONTENTS

The present systematic review was conducted and reported in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines[18] and registered on the Inplasy (International Platform of Registered Systematic Review and Meta-analysis Protocols) platform, with protocol number 202330091.

Studies that used IT as a method for the assessment of adult patients with OFP were considered eligible. Clinical trials, case-control studies, cohort studies and clinical cases with more than three patients were included. No restrictions on language or year of publication were applied. The exclusion criteria were (1) literature review studies, systematic review, letters to the editor, book chapters, clinical cases with up to three patients; (2) animal studies; (3) *ex-vivo* or *in-vitro* laboratory studies; (4) studies with a population under 18 years of age; (5) studies that did not meet the aim of this systematic review; (6) studies without a control group; (7) studies in which IT was applied in different regions of the orofacial region; (8) studies in which IT was used to evaluate and/or compare treatments and (9) studies without another method of evaluating and comparing the intensity of OFP of neuropathic or musculoskeletal origin.

The guiding question of this systematic review (PECO question) was: "Can infrared thermography replace other assessment methods for OFP intensity in adult patients?" Where "P" (population) referred to adult patients with history of neuropathic or musculoskeletal OFP; "E" (exposure) referred to exposure to the IT exam; "C" (control) referred to other methods for assessment of OFP intensity; and "O" (outcome) referred to the correlation of IT with other methods for assessment of OFP intensity.

**Search strategy**

Five electronic databases were searched to identify studies with potential relevance: PubMed, Scielo, Web of Science, SciVerse Sco-

pus and Cochrane Library. Mesh (Medical Subject Headings) and non-Mesh descriptors were used to define the key words related to "Orofacial Pain" and "Infrared Thermography". The Boolean operators "OR" and "AND" were used when crossing key words. Additional searches were conducted in the gray literature (OpenGrey), on the Google Scholar platform and a manual search was made of the references of the studies included. Table 1 presents the search strategy in the different databases.

**Selection of studies and data extraction**

After collecting references from all databases and removing duplicates, the first stage of evaluating articles began, based on titles and abstracts. Two calibrated and independent authors (JPA and SMP) performed this step. The studies that did not meet the inclusion criteria were excluded.

The studies considered relevant were obtained in full for reading and were assessed relative to whether they would be included

**Table 1.** Search strategies for all databases

| | |
|---|---|
| Pubmed | (Facial Pain) OR (Facial Neuralgia) OR (Myofascial Pain Syndromes) OR (Trigeminal Neuralgia) OR (Neuralgia) OR (Myalgia) OR (Muscular Diseases) OR (Musculoskeletal Diseases) OR (Temporomandibular Joint Dysfunction Syndrome) OR (Temporomandibular Joint Disorders) OR (Joint Diseases) OR (Craniomandibular Disorders) OR (Cranial Nerve Diseases) OR (Trigeminal Nerve Diseases) OR (Trigger Points) OR (Face Pain) OR (Orofacial Pain) OR (Neuralgic Facial Pain) OR (Craniofacial Pain) OR (Myofacial Pain) OR (Craniofacial Pain Syndrome) OR (Facial Pain Syndrome) OR (Myofacial Pain Syndrome) OR (Myofascial Pain Syndrome) OR (Myofascial Trigger Point Pain) OR (Trifacial Neuralgia) OR (Neuropathic Pain) OR (Nerve Pain) OR (Muscle Pain) OR (Muscle Soreness) OR (Muscle Tenderness) OR (Muscular Disease) OR (Myopathy) OR (Muscle Disorder) OR (Myopathic Condition) OR (Musculoskeletal Disease) OR (Orthopedic Disorder) OR (Myofascial Pain Dysfunction Syndrome) OR (TMJ Syndrome) OR (Temporomandibular Joint Syndrome) OR (Temporomandibular Joint Disorder) OR (TMJ Disorder) OR (Temporomandibular Disorder) OR (Temporomandibular Joint Disease) OR (TMJ Disease) OR (Joint Disease) OR (Arthropathy) OR (Craniomandibular Disorder) OR (Craniomandibular Disease) OR (Cranial Nerve Disease) OR (Nervus Cranialis Disorder) OR (Cranial Nerve Disorder) OR (Cranial Neuropathy) OR (Multiple Cranial Neuropathy) OR (Cranial Nerve Palsy) OR (Trigeminal Nerve Disease) OR (Trigeminal Neuropathy) OR (Trigeminal Nerve Disorder) OR (Cranial Nerve V Diseases) OR (Fifth Cranial Nerve Diseases) OR (Trigger Point) OR (Trigger Area) AND (Thermography) OR (Thermometry) OR (Infrared Thermography) OR (Temperature Mapping) OR (Infrared Thermometry) OR (Infrared Measurement) OR (Infrared Thermography Diagnosis) OR (Infrared Thermography Oral) OR (Infrared Thermography Pain) OR (Infrared Thermography Injury) OR (Infrared Thermography Dentistry) OR (Infrared Termal Imaging) OR (Digital Infrared Termal) OR (Infrared Thermal Image) OR (Thermography Diagnosis) OR (Thermography Myofascial) OR (Thermography Orofacial) OR (Infrared Imaging) OR (Infrared Image) OR (Temperature Infrared) OR (Infrared Temperature Measurement). |
| Scielo | (Facial Pain OR Facial Neuralgia OR Myofascial Pain Syndromes OR Trigeminal Neuralgia OR Neuralgia OR Myalgia OR Muscular Diseases OR Musculoskeletal Diseases OR Temporomandibular Joint Dysfunction Syndrome OR Temporomandibular Joint Disorders OR Joint Diseases OR Craniomandibular Disorders OR Cranial Nerve Diseases OR Trigeminal Nerve Diseases OR Trigger Points OR Face Pain OR Orofacial Pain OR Neuralgic Facial Pain OR Craniofacial Pain OR Myofacial Pain OR Craniofacial Pain Syndrome OR Facial Pain Syndrome OR Myofacial Pain Syndrome OR Myofascial Pain Syndrome OR Myofascial Trigger Point Pain OR Trifacial Neuralgia OR Neuropathic Pain OR Nerve Pain OR Muscle Pain OR Muscle Soreness OR Muscle Tenderness OR Muscular Disease OR Myopathy OR Muscle Disorder OR Myopathic Condition OR Musculoskeletal Disease OR Orthopedic Disorder OR Myofascial Pain Dysfunction Syndrome OR TMJ Syndrome OR Temporomandibular Joint Syndrome OR Temporomandibular Joint Disorder OR TMJ Disorder OR Temporomandibular Disorder OR Temporomandibular Joint Disease OR TMJ Disease OR Joint Disease OR Arthropathy OR Craniomandibular Disorder OR Craniomandibular Disease OR Cranial Nerve Disease OR Nervus Cranialis Disorder OR Cranial Nerve Disorder OR Cranial Neuropathy OR Multiple Cranial Neuropathy OR Cranial Nerve Palsy OR Trigeminal Nerve Disease OR Trigeminal Neuropathy OR Trigeminal Nerve Disorder OR Cranial Nerve V Diseases OR Fifth Cranial Nerve Diseases OR Trigger Point OR Trigger Area) AND (Thermography OR Thermometry OR Infrared Thermography OR Temperature Mapping OR Infrared Thermometry OR Infrared Measurement OR Infrared Thermography Diagnosis OR Infrared Thermography Oral OR Infrared Thermography Pain OR Infrared Thermography Injury OR Infrared Thermography Dentistry OR Infrared Termal Imaging OR Digital Infrared Termal OR Infrared Thermal Image OR Thermography Diagnosis OR Thermography Myofascial OR Thermography Orofacial OR Infrared Imaging OR Infrared Image OR Temperature Infrared OR Infrared Temperature Measurement) |
| Web of Science | (Facial Pain OR Facial Neuralgia OR Myofascial Pain Syndromes OR Trigeminal Neuralgia OR Neuralgia OR Myalgia OR Muscular Diseases OR Musculoskeletal Diseases OR Temporomandibular Joint Dysfunction Syndrome OR Temporomandibular Joint Disorders OR Joint Diseases OR Craniomandibular Disorders OR Cranial Nerve Diseases OR Trigeminal Nerve Diseases OR Trigger Points OR Face Pain OR Orofacial Pain OR Neuralgic Facial Pain OR Craniofacial Pain OR Myofacial Pain OR Craniofacial Pain Syndrome OR Facial Pain Syndrome OR Myofacial Pain Syndrome OR Myofascial Pain Syndrome OR Myofascial Trigger Point Pain OR Trifacial Neuralgia OR Neuropathic Pain OR Nerve Pain OR Muscle Pain OR Muscle Soreness OR Muscle Tenderness OR Muscular Disease OR Myopathy OR Muscle Disorder OR Myopathic Condition OR Musculoskeletal Disease OR Orthopedic Disorder OR Myofascial Pain Dysfunction Syndrome OR TMJ Syndrome OR Temporomandibular Joint Syndrome OR Temporomandibular Joint Disorder OR TMJ Disorder OR Temporomandibular Disorder OR Temporomandibular Joint Disease OR TMJ Disease OR Joint Disease OR Arthropathy OR Craniomandibular Disorder OR Craniomandibular Disease OR Cranial Nerve Disease OR Nervus Cranialis Disorder OR Cranial Nerve Disorder OR Cranial Neuropathy OR Multiple Cranial Neuropathy OR Cranial Nerve Palsy OR Trigeminal Nerve Disease OR Trigeminal Neuropathy OR Trigeminal Nerve Disorder OR Cranial Nerve V Diseases OR Fifth Cranial Nerve Diseases OR Trigger Point OR Trigger Area) AND (Thermography OR Thermometry OR Infrared Thermography OR Temperature Mapping OR Infrared Thermometry OR Infrared Measurement OR Infrared Thermography Diagnosis OR Infrared Thermography Oral OR Infrared Thermography Pain OR Infrared Thermography Injury OR Infrared Thermography Dentistry OR Infrared Termal Imaging OR Digital Infrared Termal OR Infrared Thermal Image OR Thermography Diagnosis OR Thermography Myofascial OR Thermography Orofacial OR Infrared Imaging OR Infrared Image OR Temperature Infrared OR Infrared Temperature Measurement) |

Continue...

**Table 1.** Search strategies for all databases – continued

| | |
|---|---|
| SciVerse Scopus | Facial Pain OR Facial Neuralgia OR Myofascial Pain Syndromes OR Trigeminal Neuralgia OR Neuralgia OR Myalgia OR Muscular Diseases OR Musculoskeletal Diseases OR Temporomandibular Joint Dysfunction Syndrome OR Temporomandibular Joint Disorders OR Joint Diseases OR Craniomandibular Disorders OR Cranial Nerve Diseases OR Trigeminal Nerve Diseases OR Trigger Points OR Face Pain OR Orofacial Pain OR Neuralgic Facial Pain OR Craniofacial Pain OR Myofacial Pain OR Craniofacial Pain Syndrome OR Facial Pain Syndrome OR Myofacial Pain Syndrome OR Myofascial Pain Syndrome OR Myofascial Trigger Point Pain OR Trifacial Neuralgia OR Neuropathic Pain OR Nerve Pain OR Muscle Pain OR Muscle Soreness OR Muscle Tenderness OR Muscular Disease OR Myopathy OR Muscle Disorder OR Myopathic Condition OR Musculoskeletal Disease OR Orthopedic Disorder OR Myofascial Pain Dysfunction Syndrome OR TMJ Syndrome OR Temporomandibular Joint Syndrome OR Temporomandibular Joint Disorder OR TMJ Disorder OR Temporomandibular Disorder OR Temporomandibular Joint Disease OR TMJ Disease OR Joint Disease OR Arthropathy OR Craniomandibular Disorder OR Craniomandibular Disease OR Cranial Nerve Disease OR Nervus Cranialis Disorder OR Cranial Nerve Disorder OR Cranial Neuropathy OR Multiple Cranial Neuropathy OR Cranial Nerve Palsy OR Trigeminal Nerve Disease OR Trigeminal Neuropathy OR Trigeminal Nerve Disorder OR Cranial Nerve V Diseases OR Fifth Cranial Nerve Diseases OR Trigger Point OR Trigger Area AND Thermography OR Thermometry OR Infrared Thermography OR Temperature Mapping OR Infrared Thermometry OR Infrared Measurement OR Infrared Thermography Diagnosis OR Infrared Thermography Oral OR Infrared Thermography Pain OR Infrared Thermography Injury OR Infrared Thermography Dentistry OR Infrared Termal Imaging OR Digital Infrared Termal OR Infrared Thermal Image OR Thermography Diagnosis OR Thermography Myofascial OR Thermography Orofacial OR Infrared Imaging OR Infrared Image OR Temperature Infrared OR Infrared Temperature Measurement |
| Cochrane Library | (Facial Pain OR Facial Neuralgia OR Myofascial Pain Syndromes OR Trigeminal Neuralgia OR Neuralgia OR Myalgia OR Muscular Diseases OR Musculoskeletal Diseases OR Temporomandibular Joint Dysfunction Syndrome OR Temporomandibular Joint Disorders OR Joint Diseases OR Craniomandibular Disorders OR Cranial Nerve Diseases OR Trigeminal Nerve Diseases OR Trigger Points OR Face Pain OR Orofacial Pain OR Neuralgic Facial Pain OR Craniofacial Pain OR Myofacial Pain OR Craniofacial Pain Syndrome OR Facial Pain Syndrome OR Myofacial Pain Syndrome OR Myofascial Pain Syndrome OR Myofascial Trigger Point Pain OR Trifacial Neuralgia OR Neuropathic Pain OR Nerve Pain OR Muscle Pain OR Muscle Soreness OR Muscle Tenderness OR Muscular Disease OR Myopathy OR Muscle Disorder OR Myopathic Condition OR Musculoskeletal Disease OR Orthopedic Disorder OR Myofascial Pain Dysfunction Syndrome OR TMJ Syndrome OR Temporomandibular Joint Syndrome OR Temporomandibular Joint Disorder OR TMJ Disorder OR Temporomandibular Disorder OR Temporomandibular Joint Disease OR TMJ Disease OR Joint Disease OR Arthropathy OR Craniomandibular Disorder OR Craniomandibular Disease OR Cranial Nerve Disease OR Nervus Cranialis Disorder OR Cranial Nerve Disorder OR Cranial Neuropathy OR Multiple Cranial Neuropathy OR Cranial Nerve Palsy OR Trigeminal Nerve Disease OR Trigeminal Neuropathy OR Trigeminal Nerve Disorder OR Cranial Nerve V Diseases OR Fifth Cranial Nerve Diseases OR Trigger Point OR Trigger Area) AND (Thermography OR Thermometry OR Infrared Thermography OR Temperature Mapping OR Infrared Thermometry OR Infrared Measurement OR Infrared Thermography Diagnosis OR Infrared Thermography Oral OR Infrared Thermography Pain OR Infrared Thermography Injury OR Infrared Thermography Dentistry OR Infrared Termal Imaging OR Digital Infrared Termal OR Infrared Thermal Image OR Thermography Diagnosis OR Thermography Myofascial OR Thermography Orofacial OR Infrared Imaging OR Infrared Image OR Temperature Infrared OR Infrared Temperature Measurement) |
| Google Schoolar | Orofacial Pain AND Infrared Thermography |
| Gray literature | Orofacial Pain AND Infrared Thermography |

in this review. In case of disagreement between the authors, the decision was made by consensus and by evaluation of a third author. After applying the eligibility criteria, 65 articles were selected for reading in full. Of these, 64 articles were available for complete reading and conclusion of the second stage. The ResearchGate platform was used to contact the authors of the only article not found, and a positive response was obtained. A manual search was also performed, which did not result in the inclusion of articles.

Data were extracted by the same two authors, independently. In case of divergence, a third author stipulated consensus. The following data were extracted: name of the author(s), year of publication, country, study design, sample size, groups evaluated, symptomatological conditions, orofacial regions/muscles/points evaluated, thermography acquisition protocols (environmental specifications, patient specifications, regions examined), other exams performed, criteria for measuring temperature, criteria for measuring the intensity of OFP, results found and conclusion. In case of any information not obtained in the articles, the term "not informed" was used.

**Evaluation of risk of bias**

Assessments of methodological quality and risk of bias for each study were carried out by two reviewers, independently, using the Joanna Briggs scale for analytical cross-sectional studies. In case of divergence, the supervisor established consensus. This scale was made up of nine questions (items) and for each item, the reviewers assigned four possible types of answers, namely: "Yes", "No", "Not clear" and "Not applicable". The evaluators were calibrated regarding the parameters established for each of the possible answers and the scores assigned were: "Yes" = 1, "No" = 0, "Not clear" and "Not applicable" = 0.

After judging the items, the evaluators defined the overall methodological quality of each study in order to classify them as "Good", "Moderate" or "Poor", based on an overall score of "Yes" answers. The answers obtained were interpreted according to the methodology of a reference study[19], which considered that if the overall score was < 50%, the article should be classified as "bad", if it was between 50% and 80% it would be "moderate", and if it was > 80% it would be "good".

## RESULTS

The PRISMA flowchart with presentation of the study selection process throughout the systematic review is illustrated in figure 1. After screening 7,194 in all databases, 65 articles were pre-selected for reading in full and analysis. Of these, 60 were excluded because they did not meet the eligibility criteria, and five articles were included for this review.

The sample size of the five studies included ranged from 23 to 86 patients[8,20]. Four studies described the gender and age of the patients evaluated, one with women aged 22 to 82 years[21], one with women aged 18 to 40 years[22], one with women from 33 to 49 years old[8], one with both genders from 18 to 60 years old[20]. One study did not inform the gender and age of the participants[23]. Four studies were conducted in patients with TMD and without TMD[8,20,22,23] and one was conducted in patients with myofacial trigger points[21].

Four studies used acquisition protocols for thermographic images, with three studies citing the protocol recommended by the Academy of Neuro-Muscular Thermography[8,21,23], one used the American Academy of Thermology reference[20] and one study used its own protocol[22].

Three studies used VAS[8,21,22] as a criterion for measuring pain intensity, two studies used NRS[20,23]. Four studies reported an association between the intensity of OFP and temperature[8,20,21,23]. One article showed that patients with TMD and pain had increased temperature compared to normal individuals without pain[23], while the others demonstrated a decrease in temperature with increasing pain intensity[8,20,21]. In only one study, pain intensity was not significantly associated with temperature[22]. Table 2 presents the information extracted from the studies included in the present review.

Considering the application of the Joanna Briggs scale to evaluate the studies included, the general results suggested a moderate quality, since the studies presented a mean score ranging from 6 to 7 points (66.66% to 77.77%) out of a total of 9 points (100%). No study showed a high risk of bias, according to the evaluation parameters used[19]. The questions that most affected the scores were: "Was the sample size adequate?", for which no study demonstrated appropriate sample size calculation or repre-

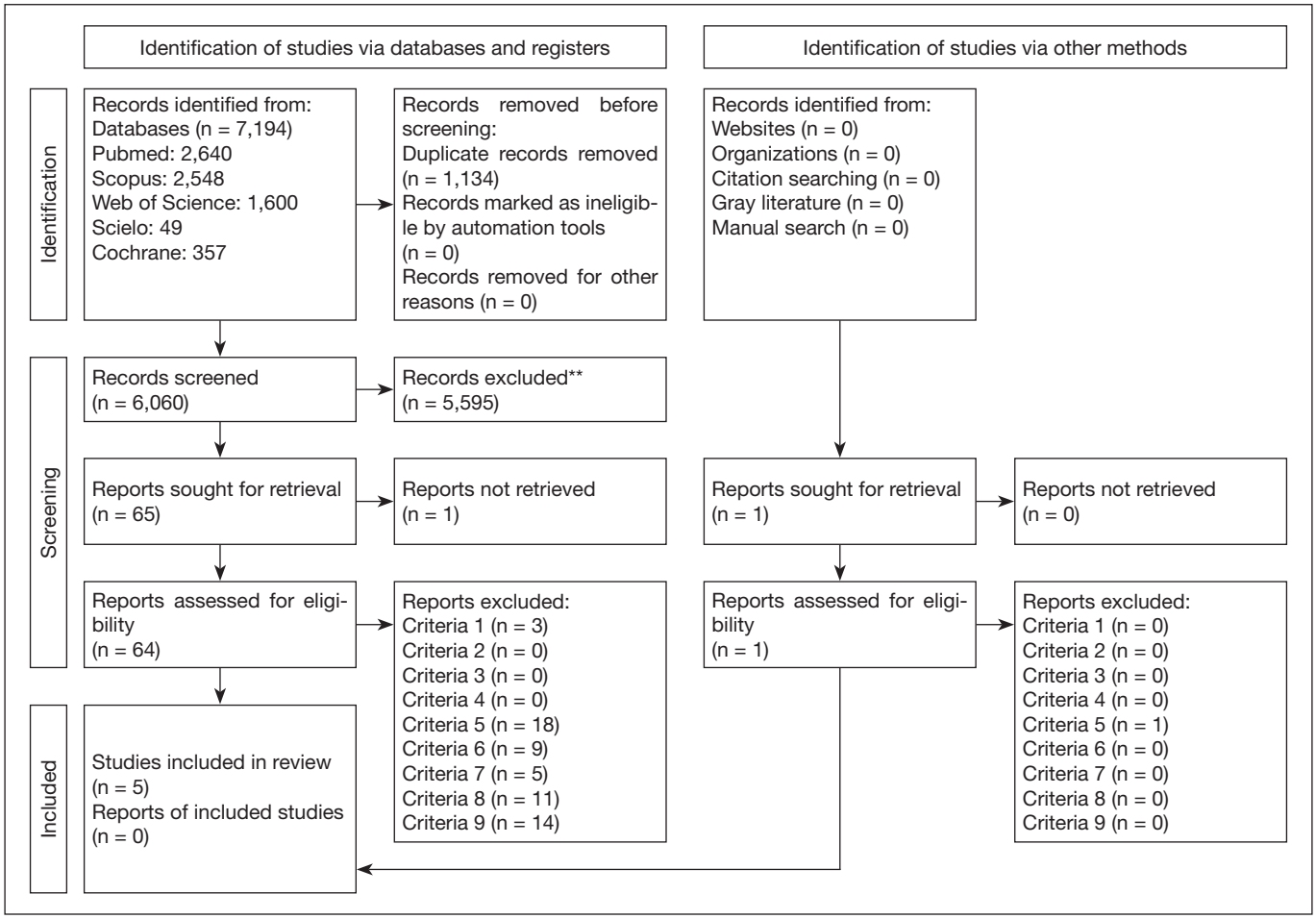


**Figure 1**. PRISMA 2020 flowchart to present the study selection process throughout the systematic review

Subtitles - Criterion 1: literature review studies, systematic review, letter to the editor, book chapter, clinical case with up to three patients; Criterion 2: animal studies; Criterion 3: ex-vivo or in-vitro laboratory studies; Criterion 4: studies with a population under 18 years of age; Criterion 5: studies that do not meet the aim of the systematic review; Criterion 6: studies without a control group; Criterion 7: studies in which IT was applied in different regions of the orofacial region; Criterion 8: studies in which IT was used to evaluate and/or compare treatments; and Criterion 9: studies without another method of evaluating and comparing the intensity of OFP of neuropathic and musculoskeletal origin.

**Table 2.** Compiled from data extraction from articles included in this systematic review

| | Canavan and Gratt[23] | Haddad, Brioschi and Arita[21] | Dibai-Filho et al.[22] | Haddad et al.[8] | Barbosa et al.[20] |
|---|---|---|---|---|---|
| Country | USA | Brazil | Brazil | Brazil | Brazil |
| Study Design | Randomized clinical study | Cross-sectional study | Not informed | Double blind study | Cross-sectional study |
| Sample size | 44 | 26 | 40 | 23 | 86 |
| Groups evaluated | Patients with and without TMD. | Adult women aged from 22 to 82 years. | Women with and without myogenic TMD, aged from 18 to 40 years. | Women with and without myogenic TMD, aged from 33 to 49 years. | Patients with and without TMD, of both genders, aged from 18 to 60 years. |
| Symptomatic conditions | Arthralgia, myofascial pain, limited mouth opening, joint sounds, and jaw locking. | Myofascial trigger points, for local pain and referred pain. | Myofascial pain, limited mouth opening, disc displacement with and without reduction, and arthralgia. | Myofascial pain. | Myofascial pain, limited mouth opening, disc displacement with and without reduction, and arthralgia. |
| Regions/muscles/ orofacial points evaluated | TMDs on both sides | Masseter and temporal muscles, on both sides. | Masseter and anterior temporal muscles, on both sides. | Masseter and anterior temporal muscles. | Masseter and anterior temporal muscles, and TMJ, on both sides. |
| Thermographic Protocols | Environmental specifications:<br>Protocol recommended by the Academy of Neuro-Muscular Thermography.<br>Patient specifications:<br>Clean and dry face; tied hair; 15 minutes of rest to balance facial temperature.<br>Equipment and Technical Parameters<br>Agema 870 infrared thermography unit.<br>Projections acquired at two sensitivities (0.5° and 1.0°C) with an accuracy of 0.1°C. | Environmental specifications:<br>Protocol recommended by the Academy of Neuro-Muscular Thermography.<br>Patient specifications:<br>Do not use cream or makeup; do not use a hair dryer or straightener; do not smoke before the exam; avoid manipulations in the face; do not drink coffee or alcoholic beverages; do not use drugs or substances that alter sympathetic function; keep the hair tied up and covered with a disposable cap.<br>During the examination, the patient remained seated, with the head positioned on a cephalostat, with the muscles relaxed and the teeth spaced apart.<br>Equipment and Technical Parameters<br>ThermaCAM T400 infrared thermography unit (FLIR Systems, Wilsonville, USA).<br>Thermal sensitivity of 0.05°C to 30°C; spectral range 7.5 µm–13 µm; special resolution of 320 × 240 pixels; camera-patient distance of 0.75 m, at an angle of 90°, with the camera lens parallel to the region to be evaluated.<br>Skin emissivity value of 0.987. | Environmental specifications:<br>The patients were acclimatized in a room at 21 °C, for 20 minutes. The room was lit by fluorescent lamps.<br>Patient specifications:<br>Avoid hot baths; creams and makeup; nasal decongestants; practice vigorous exercise and take stimulant substances before the exam.<br>During the examination, patients remained seated with their torso upright, feet flat on the floor and hands resting on their thighs, keeping the Frankfurt plane parallel to the floor. Objects were removed from the area examined and hair was kept tied up.<br>Markers were used to standardize anatomical points in the evaluated muscles.<br>Equipment and Technical Parameters<br>T360 infrared thermography unit (FLIR Systems, Danderyd, Sweden).<br>Emissivity value of 0.98; camera-patient distance of 100 cm. | Environmental specifications:<br>Protocol recommended by the Academy of Neuro-Muscular Thermography.<br>Patient specifications:<br>Do not use cream or makeup; do not use a hair dryer or straightener; do not rub or press the skin; keep the hair tied up and covered with a disposable cap.<br>During the examination, the patient remained seated, with the head positioned on a cephalostat, with the facial muscles relaxed and the teeth apart. The Frankfurt plane was kept parallel to the horizontal plane.<br>Equipment and Technical Parameters<br>ThermaCAM T400 infrared thermography unit (FLIR Systems, Wilsonville, USA).<br>Thermal sensitivity of 0.05°C at 30°C; spectral range of 7.5–12 µm; spatial resolution of 320 × 240 pixels; emissivity value of 0.98; camera-patient distance of 0.80 m, at an angle of 90°, with the camera lens parallel to the region to be evaluated. | Environmental specifications:<br>Protocol recommended by the American Academy of Thermology.<br>Patient specifications:<br>Do not use cream or makeup; do not use a hair dryer or straightener; avoid analgesics, corticosteroids, and anti-inflammatory agents; do not exercise and do not touch or rub the skin.<br>The patient remained seated for 15 minutes before capturing the images, maintaining an upright posture, with the Camper plane parallel to the horizontal plane. Facial masks were made and used as guides for anatomical demarcation of the evaluated regions.<br>Equipment and Technical Parameters<br>T650sc infrared thermography unit (FLIR Systems, Danderyd, Sweden).<br>Spatial resolution of 640 × 480 pixels; emissivity value of 0.98; camera-patient distance of 0.80 m. |

Continue...

**Table 2.** Compiled from data extraction from articles included in this systematic review – continued

| | Canavan and Gratt[23] | Haddad, Brioschi and Arita[21] | Dibai-Filho et al.[22] | Haddad et al.[8] | Barbosa et al.[20] |
|---|---|---|---|---|---|
| Country | USA | Brazil | Brazil | Brazil | Brazil |
| Other exams performed | Measurement of mouth opening (in mm).<br>Examination of jaw locking, using the following classification scale:<br>0 = without locking<br>1 = mild locking<br>2 = moderate locking<br>Examination of joint sounds, using the following classification scale:<br>0 = absence of noise<br>1 = click, one side only<br>2 = click, on both sides<br>3 = click and snap<br>Examination of pain and discomfort in joints and muscles, using a pressure algometer. | RDC/TMD.<br>Side view photographs of the face.<br>Examination to measure pain in trigger points using algometry. Each patient was instructed to report when they felt initial pain or discomfort, and if the pain was local or if it extended to another region. | RDC/TMD.<br>Pain evaluation by VAS. | RDC/TMD.<br>Digital photographs of the face.<br>Palpation.<br>Assessment of pain using VAS. | RDC/TMD.<br>Control group (without TMD) evaluated according to the Fonseca Anamnestic Index.<br>Palpation in patients with TMD, according to RDC/TMD axis I. |
| Criteria for measuring temperature | Temperatures were obtained in the TMJ regions of each individual. Calculations were made from the values of ΔT (the temperature difference between the sides). The ΔT values varied between 0° and 0.8°C, and allowed the identification of individuals with TMD. | The masseter and anterior temporal muscles were divided into 15 facial ROIs on each side.<br>All images showed a palette of 85 to 100 colors, with a thermal window of 0.15°C for each color. Thermal sensitivity of 0.51°C per color tone was used, based on a colorimetric scale. To correlate pressure pain threshold values with temperature values, thermograms were digitally superimposed on digital photographs. | The temperatures of the masseter and anterior temporal muscles were compared between the groups with and without TMD. Temperature asymmetry was determined by subtracting the temperatures on both sides. Temperature measurement was performed by a single evaluator, blind to allocation of the groups.<br>The temperatures were also correlated with pain intensity. | The infrared camera reading was interpreted by using a normalized (dimensionless) temperature, so that there was no interference from the ambient and body temperatures in the readings taken on the face. | Using mean temperature values, patients with and without TMD were compared.<br>Considering the clinical variability and asymmetry of patients affected by TMD, the absolute mean values of temperature and pain intensity on the right and left sides were subtracted from each other. Facial thermal asymmetry was classified for values higher than 0.4°C and for differences in pain level higher than 1. |
| Criteria for measuring OFP intensity | Assessment of muscle pain or discomfort was classified using the following scale:<br>0 = absence of pain<br>1 = mild discomfort<br>2 = moderate discomfort<br>3 = severe discomfort<br>Assessment of joint pain or discomfort was classified using the following scale:<br>0 = absence of pain or discomfort<br>1 = mild discomfort<br>2 = moderate discomfort<br>3 = severe discomfort | The VAS 100 mm long was used, with end points defined as “no pain” (left) and “worst pain imaginable” (right). Patients were instructed to mark the intensity of pain on this scale. All volunteers were asymptomatic on the day of the exam (VAS = 0). | The VAS was used, with the following classification:<br>0 = absence of pain<br>From 1 to 2 = mild pain<br>From 3 to 4 = moderate pain<br>5 or more = intense pain | The VAS was used for measuring pain. All volunteers were asymptomatic on the day of the exam (VAS = 0). | A NRS was used to assess the intensity of pain on palpation, with the following scores:<br>0 = No pain<br>1 = mild pain<br>2 = moderate pain<br>3 = Intense pain<br>The absolute mean temperatures were correlated with the pain scores on palpation of axis I of the RDC/TMD, for each ROI. |

Continue...

**Table 2.** Compiled from data extraction from articles included in this systematic review – continued

| | Canavan and Gratt[23] | Haddad, Brioschi and Arita[21] | Dibai-Filho et al.[22] | Haddad et al.[8] | Barbosa et al.[20] |
|---|---|---|---|---|---|
| Country | USA | Brazil | Brazil | Brazil | Brazil |
| Results | Control group with a high level of thermal symmetry in the TMJ region. Group of symptomatic patients with low level of thermal symmetry.<br>Since there was a correlation between the temperatures obtained at different points, the temperature analysis was limited to areas of the TMJ only. When TMJ ΔT values were equal to or greater than 0.3°C, the subject was classified as having TMD.<br>The results indicated that as the level of pain in the TMJ increased, the mean TMJ ΔT values also increased. Significant differences were found between individuals without joint pain (11 cases) and individuals who reported mild discomfort on palpation (8 cases), moderate discomfort on palpation (8 cases) and severe discomfort on palpation (17 cases).<br>The results of the muscle pain assessments showed no significant differences in temperature between individuals with and without mild muscle pain.<br>However, individuals with moderate and severe muscle pain demonstrated significant differences in temperature when compared to individuals with no pain or only mild muscle pain. | The pressure threshold for trigger points was lower in referred pain points than in local pain points.<br>The masseter muscle showed greater sensitivity to pain than the temporal muscle.<br>The temporal muscle was significantly more hyperthermic than the masseter.<br>Moderately significant correlations were observed between pressure and temperature values, suggesting that the greater the force applied, the higher was the local temperature recorded. Furthermore, temperatures at the local pain points were higher than they were in the areas of referred pain.<br>The areas of the face that were most heated were correlated with regions without trigger points (above 34°C). At the same time, values below 33°C were related to referred pain. Therefore, the temperature decreased according to the severity of myofascial dysfunction. | No significant correlations were found between pain intensity and skin temperature in the region of the masseter and anterior temporal muscles.<br>No significant difference in skin temperature was found between individuals with and without TMD. | Infrared imaging revealed a 1.4°C difference between the mean temperatures of the anterior temporal and masseter muscles, indicating that the temporal muscle was significantly more hyperradiant than the masseter.<br>Temperatures in the regions of the masseter and anterior temporal muscles in patients with myogenic TMD were significantly lower than those measured in volunteers in the control group.<br>The affected muscle region presented a lower temperature than the corresponding unaffected area, that is, temperatures decreased with the severity of myogenic TMD. | The values defined by IT showed a low level of accuracy for diagnosis.<br>A negative correlation was found between pain intensity and temperature in the region of the left middle masseter and left inferior masseter muscles, showing that as the pain increased, the local temperature decreased.<br>No asymmetry between temperature or pain was found in the regions evaluated in patients with TMD. |
| Conclusion | The findings of this study provided additional evidence relative to the clinical use of IT as an objective examination for the purpose of including or ruling out TMD as a cause of OFP, thus avoiding unnecessary TMD treatments.<br>The region of the TMJ of patients with TMD and pain was hotter than the same area of individuals without TMD and those who were not in pain.<br>IT showed promise as a tool to distinguish individuals with and without TMD, with sensitivity of 92%, specificity of 85% and accuracy of 89%. | The greater the force applied, the higher is the local temperature recorded.<br>Temperatures at the local pain points were higher than they were in the areas of referred pain.<br>Temperature decreased as the severity of myofascial dysfunction increased.<br>The thermographic image of the trigger point is hyporadiant when compared to that of the region without a trigger point.<br>IT made it possible to identify trigger points, by dividing them into local pain and referred pain.<br>If the thermal values are used in conjunction with physical assessment, they can serve as a means of screening and improving diagnostic accuracy in clinical practice. | The intensity of pain was not significantly associated with the temperature of skin on the masticatory muscles or asymmetries between temperatures.<br>No significant differences in temperature or asymmetry were detected between individuals with and without TMD. | The temperature of areas of the masseter and anterior temporal muscles decreases in the presence of myogenic TMD, suggesting that IT may be useful in the assessment of myogenic TMD. Moreover, it can be used as a clinical screening method for improving diagnostic accuracy. | IT did not produce results that could satisfactorily contribute to the differential diagnosis between individuals with and without TMD<br>The increase in pain intensity on palpation in patients with TMD was accompanied by a reduction in local temperature in some of the regions evaluated. |

IT = infrared thermography; NRS = numeric rating scale; OFP = orofacial pain; RDC/TMD = research diagnostic criteria for temporomandibular disorders; ROI = region of interest; TMD = temporomandibular disorder; TMJ = temporomandibular joint; VAS = visual analogue scale.

**Table 3.** Critical assessment of the methodological quality of the studies included, using the Joanna Briggs scale

| Articles | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | Overall score |
|---|---|---|---|---|---|---|---|---|---|---|
| Canavan and Gratt[23] | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 6/9 |
| Haddad, Brioschi and Arita[21] | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 7/9 |
| Dibai-Filho et al.[22] | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 7/9 |
| Haddad et al.[8] | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 7/9 |
| Barbosa et al.[20] | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 7/9 |

P1: Was the sample frame appropriate to address the target population?

P2: Were study participants sampled in an appropriate way?

P3: Was the sample size adequate?

P4: Were the study subjects and the setting described in detail?

P5: Was the data analysis conducted with sufficient coverage of the identified sample?

P6: Were valid methods used for the identification of the condition?

P7: Was the condition measured in a standard, reliable way for all participants?

P8: Was there appropriate statistical analysis?

P9: Was the response rate adequate, and if not, was the low response rate managed appropriately?

"YES" = 1, "NO" = 0, "NOT CLEAR" = 0 and "NOT APPLICABLE" = 0.

sented a large enough sample to provide high validity, and "Was data analysis performed in a sufficient portion of the sample identified?", since these data did not were presented in any of the studies in question. Table 3 presents the critical assessment of the methodological quality of the studies included.

## DISCUSSION

The variation in body temperature has been the subject of study since ancient times. During inflammation or the process of repairing traumatized tissues, nociceptive fibers can become sensitized and cause pain. The activation of nociceptors is modulated by endogenous algogenic substances (potassium, prostaglandins, leukotrienes, serotonin, bradykinin, histamine, substance P, etc.). These mediators influence the level of nerve activity, and consequently, the intensity of pain. Neuropeptides such as substance P cause vasodilation and edema and may be responsible for the skin warming produced by pain[11]. IT has been used to study a range of diseases where temperature may reflect the presence of inflammation in the underlying tissues, i.e., where blood flow is increased or decreased due to a clinical abnormality[13].

Based on the relationship established between pain, muscle activity and skin surface temperature, IT has been considered a possible diagnostic tool for assessing OFP[22], in a way that is non-ionizing, painless and safe for patients[9]. It can demonstrate cutaneous, vasomotor and neurovegetative activity, based on the capture and transformation of infrared radiation emitted by human skin into images that reflect local microcirculatory dynamics[11,24,25].

In this systematic review, three studies[8,20,23] presented significant, but different, inferences about the use of IT to assess pain intensity in patients with TMD. Painful symptoms are one of the main clinical manifestations in patients with TMD[8,20,23], who presented an asymmetrical thermal pattern when comparing the right and left sides[26,27].

The findings of a study[23] highlighted the use of IT to include or rule out TMD as a possible cause of OFP, with an accuracy of 89%. According to the authors, the TMJ region of patients with TMD and pain was hotter than the same area of individuals without TMD and pain; and as the pain level increased, the average temperature values also increased. Other studies carried out in patients with TMD also found an increase in skin temperature over the masseter and temporal muscles[14,15] and in the TMJ region[14]. According to one of these studies[28], muscular activities, spasms and contractions are indicated on thermograms as an increase in heat emission, and, consequently, an increase in temperature. When painful, TMD are generally associated with hyperthermia of the overlying skin. It is hypothesized that this skin hyperthermia, caused by regional vasodilation, is induced by nitric oxide produced in the extravascular space of the joint. Extravascular nitric oxide can be produced by osteoblasts, chondrocytes, and macrophages, or by stimulated neurons. It is suggested that this kind of pain is associated with nitric oxide-enhanced sensitivity of the peripheral nociceptors[24,29].

A study[20] evaluated, in patients with and without TMD, the correlation of temperature with the intensity of pain on palpation in the region of the TMJ and the masseter and anterior temporal muscles. The authors did not observe significant differences in the temperature of both groups (with and without TMD). When correlating temperature with the intensity of pain on palpation, they observed a negative correlation only for some regions of the masseter muscle. The authors concluded that thermography has low accuracy in differentiating patients with and without TMD. Another study[8] compared the temperature values in masseter and anterior temporal muscles region between patients with and without TMD. The authors observed that the temperature values measured in volunteers with TMD were significantly lower than those measured in individuals without TMD. The sensitivity and specificity of the thermographic assessment for the masseter region were 70% and 73%, respectively; and, for the anterior temporal region, it was 80% and 62%, respectively.

A study[21] evaluated trigger points in patients with myofascial pain and observed that the thermographic image of these points is hypo-radiant compared to the corresponding region without trigger points. In other words, the areas of the face that were warmer were correlated with regions without trigger points. The authors concluded that IT makes it possible to identify tender points and that the use of thermographic data in conjunction with physical assessment can serve as a means of screening in clinical practice.

Some authors have stated that, in cases of muscular hyperactivity, as occurs with some chewing muscles in patients with TMD, the decrease in the surface temperature of these muscles may be due to the contractile process itself that temporarily reduces muscular blood flow. Contracting skeletal muscle compresses intramuscular blood vessels. Isometric muscle contractions can cause rapid muscle fatigue due to insufficient oxygen and other nutrients[17,30]. Another study relating microcirculation and skin temperature over tender points in individuals with fibromyalgia also attributed the decrease in surface temperature in these patients to peripheral vasoconstriction that occurs around painful points due to local hypoxia[31].

In a study[22], pain intensity in women with myogenic TMD was not associated with temperature of the skin surface. No significant differences in temperature or asymmetry were detected between individuals with and without TMD. These findings were justified by the fact that IT evaluates the temperature of the skin surface, conditioned by local microcirculatory dynamics and the autonomic nervous system, which constitutes an indirect measure of blood flow. Another justification may be associated with variations in thermographic image acquisition protocols, which can directly interfere with temperature variation.

Systematic reviews prior to the present review have been proposed, but none evaluated the intensity of OFP and temperature specifically. A study[10] conducted a systematic review on the effectiveness of IT for diagnosing TMD and concluded that there were an insufficient number of studies on the reliability of this exam for diagnosing TMD. In the aforementioned review[10], the RDC/TMD exam was used to diagnose TMD. This is a precise instrument for identifying TMD in research and clinical practice. However, despite assessing pain intensity in Axis I as part of the requirements for TMD diagnosis, this information is not always presented in articles. The same situation occurs with the application of DC/TMD, which despite addressing pain intensity in Axis II, studies do not always provide this specific information. Some articles reviewed in full were excluded precisely because they did not present pain intensity data[32-36].

A study[37] carried out a systematic review on the characterization of myofascial pain syndrome and myofascial trigger points using IT. The authors found contradictory results, and in some studies no difference was observed in the temperature of patients with trigger points compared to control patients. In other studies, there was an increase in temperature in the trigger point regions, when compared to the unaffected contralateral areas. A study[38] conducted a systematic review with meta-analysis on IT as a method for assessment of musculoskeletal and temporomandibular disorders. The authors concluded that, in general, healthy individuals showed subtle thermal differences between sides. Another study[39] evaluated IT as a useful tool for diagnosing pain syndromes of the back and neck. It was concluded that IT could diagnose changes in inflammatory activity and could be used as a tool to monitor the effectiveness of treatment and for identifying deviations from a healthy state. Other study[40] analyzed changes in skin temperature at specific acupuncture points in patients with primary dysmenorrhea and healthy individuals using IT. It was concluded that patients with dysmenorrhea showed differences in skin temperature in some areas compared to healthy individuals.

The literature on the reliability of IT in assessing pain intensity is controversial, considering the variable temperature records in OFP. According to a study[11], IT is not the sole answer to all diagnostic dilemmas of pain-producing conditions. It is just one of the procedures that the clinician can use to assess the patient. Additional information from IT can lead to a reduction in invasive tests and direct treatment towards more successful outcomes.

Some limiting questions in this review were the small amount of evidence found, eligible studies with a small sample size, and the subjectivity of pain assessment itself. The lack of a standardized protocol for measuring temperature and the need for adequate professional training for the purpose of acquisition and evaluation of thermograms have become limiting factors of IT. Temperature values are directly affected by environmental and patient conditions, which can lead to inaccurate body temperature data being obtained and analyzed by the technique[10]. Although some studies have observed that the use of IT was reliable, there is still a scarcity of literature concerning the accuracy of this diagnostic instrument for assessing pain intensity.

## CONCLUSION

The studies included in this systematic review showed variable records of temperature measured by IT in the presence of painful symptoms. Therefore, at the present, IT does not replace other methods for the assessment of pain intensity, however, it is an important ally for complementing diagnostic methods.

## AUTHORS' CONTRIBUTIONS

**Julia Pereira Americano**
Data Collection, Research, Methodology, Writing - Preparation of the Original, Writing - Review and Editing, Validation
**Sofia Melo Pires**
Data Collection, Methodology, Writing - Preparation of the Original, Writing - Review and Editing
**Luciano Ambrósio Ferreira**
Data Collection, Research, Methodology, Writing - Preparation of the Original, Writing - Review and Editing, Validation
**Karina Lopes Devito**
Data Collection, Project Management, Research, Methodology, Writing - Preparation of the Original, Writing - Review and Editing, Supervision, Validation

## REFERENCES


1. De Rossi S. Orofacial pain: a primer. Dent Clin North Am. 2013;57(3):383-92.
2. Shaefer JR, Khawaja SN, Bavia PF. Sex, gender, and orofacial pain. Dent Clin North Am. 2018;62(4):665-82.
3. Hadlaq EM, Khan H, Mubayrik AB, Almuflehi NS, Mawardi H. Dentists' knowledge of chronic orofacial pain. Niger J Clin Pract. 2019;22(10):1365-71.
4. Czaplik M, Hochhausen N, Dohmeier H, Pereira CB, Rossaint R. Development of a Thermal-Associated Pain Index score using infrared-thermography for objective pain assessment. Annu Int Conf IEEE Eng Med Biol Soc. 2017:3831-4.
5. Liang H. Imaging in orofacial pain. Dent Clin North Am. 2018;64(4):533-52.
6. Badel T, Zadravec D, Bašić Kes V, Smoljan M, Kocijan Lovko S, Zavoreo I, Krapac L, Anić Milošević S. Orofacial pain – diagnostic and therapeutic challenges. Acta Clin Croat. 2019;58(Suppl 1):82-9.
7. Schiffman E, Ohrbach R, Truelove E, Look J, Anderson G, Goulet JP, List T, Svensson P, Gonzalez Y, Lobbezoo F, Michelotti A, Brooks SL, Ceusters W, Drangsholt M, Ettlin D, Gaul C, Goldberg LJ, Haythornthwaite JA, Hollender L, Jensen R, John MT, De Laat A, de Leeuw R, Maixner W, van der Meulen M, Murray GM, Nixdorf DR, Palla S, Petersson A, Pionchon P, Smith B, Visscher CM, Zakrzewska J, Dworkin SF; International RDC/TMD Consortium Network, International association for Dental Research; Orofacial Pain Special Interest Group, International Association for the Study of Pain. Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) for Clinical and Research Applications: recommendations of the International RDC/TMD Consortium Network* and Orofacial Pain Special Interest Group†. J Oral Facial Pain Headache. 2014 Winter;28(1):6-27.
8. Haddad DS, Brioschi ML, Vardasca R, Weber M, Crosato EM, Arita ES. Thermography characterization of masticatory muscle regions in volunteers with and without myogenous temporomandibular disorder: preliminary results. Dentomaxilofac Radiol. 2014;43(8);20130440.
9. Manfredini D, Guarda-Nardini L, Winocur E, Piccotti F, Ahlberg J, Lobbezoo F. Research diagnostic criteria for temporomandibular disorders: a systematic review of axis I epidemiologic findings. Oral Surg Oral Med Oral Pathol Oral Radio Endod. 2011;112(4):453-62.
10. de Melo DP, Bento PM, Peixoto LR, Martins SKLD, Martins CC. Is infrared thermography effective in the diagnosis of temporomandibular disorders? A systematic review. Oral Surg Oral Med Oral Pathol Oral Radiol. 2019;127(2):185-92.
11. Taylor H, Warfield CA. Thermography of pain: instrumentation and uses. Hosp Pract (Off Ed). 1985;20(11):164-9.
12. Mongini F, Caselli C, Macrì V, Tetti C. Thermographic findings in cranio-facial pain. Headache. 1990;30(8):497-504.
13. Ring EF, Ammer K. Infrared thermal imaging in medicine. Physiol Meas. 2012;33(3):R33-46.
14. Pogrel MA, Erbez G, Taylor RC, Dodson TB. Liquid Crystal thermography as a diagnostic aid and objective monitor for TMJ dysfunction and myogenic facial pain. J Craniomandib Disord. 1989;3(2):65-70.
15. Nemcovsky CE, Benvenisti A, Gazit E. Variation of skin surface temperature over the masseter muscles in patients with myofascial pain following occlusal splint treatment. J Oral Rehabil. 1995;22(10):763-73.
16. Gratt BM, Sickles EA, Ross JB, Wexler CE, Gornbein JA. Thermographic assessment of craniomandibular disorders: diagnostic interpretation versus temperature measurement analysis. J Orofac Pain. 1994;8(3)278-88.
17. Barão VA, Gallo AK, Zuim PR, Garcia AR, Assunção WG. Effect of occlusal splint treatment on the temperature of different muscles in patients with TMD. J Prosthodont Res. 2011;55(1):19-23.
18. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart LA; PRISMA-P Group. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst Rev. 2015;4(1):1.
19. Vo MTH, Thonglor R, Moncatar TJR, Han TDT, Tejativaddhana P, Nakamura K. Fear of falling and associated factors among older adults in Southeast Asia: a systematic review. Public Health. 2023;222:215-28.
20. Barbosa JS, Amorim A, Arruda M, Medeiros G, Freitas A, Vieira L, Melo DP, Bento PM. Infrared thermography assessment of patients with temporomandibular disorders. Dentomaxillofac Radiol. 2020;49(4):20190392.
21. Haddad DS, Brioschi ML, Arita ES. Thermographic and clinical correlation of myofascial triggerpoints in the masticatory muscles. Dentomaxilofac Radiol. 2012;41:621-9.
22. Dibai-Filho AV, Costa ACS, Packer AC, Rodrigues-Bigaton D. Correlation between skin surface temperature over masticatory muscles and pain intensity in women with myogenous temporomandibular disorder. J Back Musculoskelet Rehabil. 2013;26(3):323-8.
23. Canavan D, Gratt BM. Electronic thermography for the assessment of mild and moderate temporomandibular joint dysfunction. Oral Surg Oral Med Oral Pathol. 1995;79(6):779-85.
24. Anbar M, Gratt BM. The possible role of nitric oxide in the physiopathology of pain associated with temporomandibular joint disorders. J Oral Maxillofac Surg. 1998;56(7):872-82.
25. Vargas JVC, Brioschi ML, Dias FG, Parolin MB, Mulinari-Brenner FA, Ordonez JC, et al. Metodologia normalizada para imagens médicas infravermelhas. Tecnol Física Infravermelha. 2009;52:42-7.
26. Merla A, Ciuffolo F, D'attilio M, Tecco S, Festa F, De Michele G, et al. Functional infrared imaging in the diagnosis of the myofascial pain. Conf Proc IEEE Eng Med Biol Soc. 2004:1188-1891.
27. Dibai-Filho AV, Costa AC, Packer AC, De Castro EM, Rodrigues-Bigaton D. Women with more severe degrees of temporomandibular disorder exhibit an increase in temperature over the temporomandibular joint. Saudi Dent J. 2015;27:44-9.
28. Fischer AA. Documentation of myofascial trigger points. Arch Phys Med Rehabil. 1988;69(4):286-91.
29. Arinci A, Ademoglu E, Aslan A, Mutlu-Turkoglu U, Karabulut AB, Karan A. Molecular correlates of temporomandibular joint disease. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2005;99(6):666-70.
30. Pita MS, Ribeiro AB, Garcia AR, Pedrazzi V, Zuim PRJ. Variation of surface temperature on superficial masseter and anterior temporal muscles during voluntary teeth clenching with maxillary splints of two different thicknesses. Full Dent Sci. 2013;4(16):592-8.
31. Jeschonneck M, Grohmann G, Hein G, Sprott H. Abnormal microcirculation and temperature in skin above tender points in patients with fibromyalgia. Rheumatology (Oxford). 2000;39(8):917-21.
32. Dibai Filho AV, Packer AC, Costa AC, Rodrigues-Bigaton D. Accuracy of infrared thermography of the masticatory muscles for the diagnosis of myogenous temporomandibular disorder. J Manipulative Physiol Ther. 2013;36(4):245-52.
33. Haddad DS, Arita ES, Pinho JC, Brioschi ML, Gabriel J, Vardasca R. The facial thermal effect of dynamic mechanical and vascular provocation tests: Preliminary study. IEEE International Symposium on Medical Measurements and Applications (MeMeA), 2014.
34. Dibai-Filho AV, Costa ACS, Packer AC, Rodrigues-Bigaton D. Correlation between skin surface temperature over masticatory muscles and pain intensity in women with myogenous temporomandibular disorder. J Back Musculoskelet Rehabil. 2013;26(3):323-8.
35. Rodrigues-Bigaton D, Dibai-Filho AV, Packer AC, Costa ACS, Castro EM. Accuracy of two forms of infrared image analysis of the masticatory muscles in the diagnosis of myogenous temporomandibular disorder. J Bodyw Mov Ther. 2014;189(1):49-55.
36. Woźniak K, Szyszka-Sommerfeld L, Trybek G, Piątkowska, D. Assessment of the sensitivity, specificity, and accuracy of thermography in identifying patients with TMD. Med Sci Monit. 2015;21:1485-93.
37. Mazza DF, Boutin RD, Chaudhari AJ. Assessment of myofascial trigger points via imaging: a systematic review. Sou J Phys Med Rehabil. 2021;100(10):1003-14.
38. Moreira A, Batista R, Oliveira S, Branco CA, Mendes J, Figueiral MH. Role of thermography in the assessment of temporomandibular disorders and other musculoskeletal conditions: a systematic review. Proc Inst Mech Eng H. 2021;235(100):1099-112.
39. Albuquerque NF, Lopes BS. Musculoskeletal applications of infrared thermography on back and neck syndromes: a systematic review. Eur J Phys Rehabil Med. 2021;57(3):386-96.
40. Wang X, Zuo G, Liu J, Zhang J, Shi X, Fan X, Li X, Gao Y, Chen H, Liu CZ, She Y. Skin temperature of acupoints in health and primary dysmenorrhea patients: a systematic review and meta-analysis. J Pain Res. 2023;16:2027-46.