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NARRATIVE REVIEW

The Role of Infrared Thermography in the Diagnosis of Temporomandibular Disorders: A Narrative Review

El papel de la Termografía infrarroja en el diagnóstico de Trastornos Temporomandibulares: Revisión Narrativa

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Keywords: Periodontitis; periodontal disease; HIV, antiretroviral therapy; ART; highly active antiretroviral therapy; HAART.

ABSTRACT

Background: Temporomandibular disorders are a group of musculoskeletal conditions that cause pain and dysfunction in the masticatory muscles, in the temporomandibular joint and in associated anatomical regions, its global prevalence is approximately 5-12% of population, thus generating the most common type of non odontogenic orofacial pain, which in turn increases the costs of care in health systems and reduces the quality of life. These pathologies due to physiological processes of pain and abnormal function can generate changes in temperature, which is why an emerging technological tool called Infrared Thermography has been evaluated in its assessment, which allows measuring temperatures at a distance, which could help in a clinical diagnosis. Multiple clinical trials have made use of this technology based on the thermal heterogeneity of different tissues and their blood flow, which are directly proportional to metabolic activity, which is why it is necessary to review the literature, advances and results of these studies.
Objective: To provide a general description of the main findings and conclusions of the available clinical evidence on the effectiveness of infrared thermography in the diagnosis of temporomandibular disorders.
Materials and Methods: The initial search included 62 articles, of which 11 were selected for this review, distributed in North America 38%, in Europe 14% and 48% in South America. An extensive electronic search was conducted in the databases: Pubmed, Epistemonikos and Cochrane Library.
Conclusion: Most of the studies evaluated have concluded thermography as a promising technology in the diagnosis of temporomandibular joint disorders, the literature is highly variable in reliability criteria for the use of this instrument for the diagnosis of temporomandibular joint disorders, which is is reflected in sensitivity and specificity values with widely marked differential ranges.

CLINICAL RELEVANCE

Temporomandibular joint disorders cause the most common type of non-odontogenic orofacial pain, generating great costs in the quality of life and health systems, whose diagnosis involves multiple tests, long periods of time and the use of highly ionizing technologies, making the study of alternative diagnostic aids of great clinical utility.

INTRODUCTION

Temporomandibular disorders (TMD) are a general term that encompasses a group of musculoskeletal and neuromuscular conditions that affect the masticatory musculature, the temporomandibular joint (TMJ) and/or its associated structures.[1] It is estimated that this public health problem affects approximately 5-12% of the population [2] and its etiology is multifactorial; they are considered disorders of musculoskeletal origin and can cause great deterioration in the general health of individuals and represent great costs for health systems. These disorders can be classified as muscular or articular in origin depending on the region affected.[3]

Currently the worldwide accepted diagnostic tools are the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) and the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD).[4] These disorders, due to physiological processes of pain and abnormal function, can generate changes in temperature, which can be quantified allowing the identification of a sick subject and a healthy one, for which an emerging technological tool called Infrared Thermography has been evaluated in its assessment, which allows measuring temperatures at a distance and without the need of physical contact with the object to be studied, which could help in a clinical diagnosis.

Infrared thermography is a technology (IT) that allows measuring temperatures at a distance and without the need for physical contact with the object to be studied, by capturing the intensity of infrared radiation emitted by each body, using thermographic sensors that convert the radiated energy, invisible to the human eye, into a visible image formed from the surface temperature of the objects captured by the camera, by means of software. Such technology has been used in medicine based on biothermal processes to assess health or disease, based on the microcirculatory dynamics that generate changes in temperature respectively. Consequently, disorders affecting blood flow also produce temperature changes in specific areas,[5] allowing a two-dimensional real-time measurement of temperature. Infrared thermography is a non-invasive, painless, non-ionizing and low-cost test.[6]

Multiple authors have conducted clinical studies with the aim of evaluating the effectiveness of infrared thermography in the diagnosis of temporomandibular disorders, the results of which are highly controversial and present a wide variety of diffuse conclusions.

The aim of the present study was to conduct a literature review to make an overview of the main findings and conclusions of the available clinical evidence on the effectiveness of infrared thermography in the diagnosis of temporomandibular disorders, taking into account the evidence available until September 2023 and answering the following question: What are the conclusions and main findings of controlled clinical studies and randomized clinical trials regarding the effectiveness of infrared thermography in the diagnosis of temporomandibular disorders?

MATERIALS AND METHODS

The present narrative review focused the research question on the main findings and conclusions of the available clinical evidence on the effectiveness of infrared thermography in the diagnosis of temporomandibular disorders and the analysis of the scientific evidence of the use of this tool in the diagnosis of TMD.

Search strategy and eligibility criteria

An electronic search of PubMed/MEDLINE, Cochrane and Epistemonikos databases was performed until September 22, 2023 to find relevant records. The present study had as inclusion criteria randomized clinical studies (RCT'S) and original Controlled Clinical Studies, conducted in humans published in any language and publication date until September 22, 2023, where the sample included in the research makes use of IT whose objective is the diagnosis of TMD. The exclusion criteria were as follows: Articles based on animal studies, preclinical studies, literature reviews and/or meta-analyses, and case reports.
For the PubMed/MEDLINE search, the following search strategy combining Medical Subject Headings (MeSH), search terms and natural language keywords was used:

("thermographies"[All Fields] OR "thermography"[MeSH Terms] OR "thermography"[All Fields]) AND ("temporomandibular joint disorders"[MeSH Terms] OR ("temporomandibular"[All Fields] AND "joint"[All Fields] AND "disorders"[All Fields]) OR "temporomandibular joint disorders"[All Fields] OR ("temporomandibular"[All Fields] AND "joint"[All Fields] AND "disorder"[All Fields]) OR "temporomandibular joint disorder"[All Fields]) AND (sensitiv*[Title/Abstract] OR sensitivity and specificity[MeSH Terms] OR diagnose[Title/Abstract] OR diagnosed[Title/Abstract] OR diagnoses[Title/Abstract] OR diagnosing[Title/Abstract] OR diagnosis[Title/Abstract] OR diagnostic[Title/Abstract] OR diagnosis[MeSH:noexp] OR (diagnostic equipment[MeSH:noexp] OR diagnostic errors[MeSH:noexp] OR diagnostic imaging[MeSH:noexp] OR diagnostic services[MeSH:noexp]) OR diagnosis, differential[MeSH:noexp] OR diagnosis[Subheading:noexp])

The following keywords were used for the search in Cochrane and Epistemonikos:

- Thermography

 AND

- Temporomandibular joint disorder.

Relevant references were collected and related studies were recorded by initial screening in a template for further selection. Subsequently, studies were independently screened by one reviewer (M.R) and subsequently verified by the other reviewers (B.J., C.A.).

Data extraction and collection

Data were extracted by an independent reviewer (M.R.) using a standardized data extraction form. These were subsequently verified by the other reviewers (B.J., C.A.). In case of disagreement, the reviewers resolved it by discussion to reach a consensus.

For each record, data were collected on the author, year of publication, type of study, methodology, results, control or comparison tool, population studied, and equipment used.

RESULTS

Selection of studies

A total of 62 records were found in the electronic search, 48 in PubMed/MEDLINE, 6 in Cochrane and 8 in the Epistemonikos database; 8 duplicate records were eliminated before screening. The remaining 54 titles and abstracts were reviewed, and 23 were excluded because they did not relate temporomandibular disorders diagnosis using infrared thermography. The full texts of the remaining 31 screened reports were evaluated for eligibility. Subsequently, 20 articles were excluded because they were systematic reviews, critical reviews, scoping reviews, clinical study registries or did not have the text available. Finally, 11 studies were included (Figure 1).

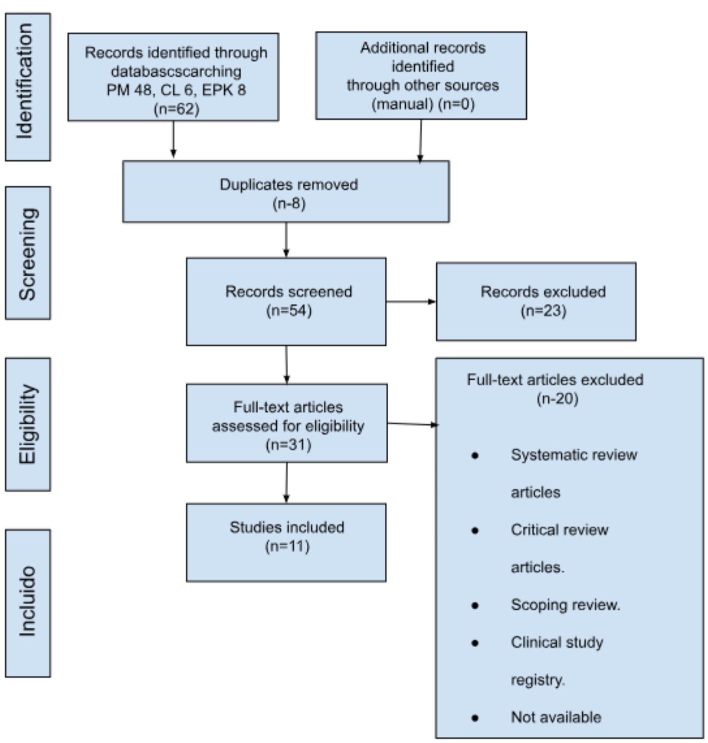

Figure 1. PRISMA 2020 flowchart for the identification of studies through databases

The main studies reporting the use of infrared thermography in the diagnosis of temporomandibular disorders that were excluded because they did not meet the inclusion criteria are appended in Supplementary Table 1.

Table 1. Characteristics of the included studies, identification of author, journal and year of publication, and synthesis of the main conclusion(s) on the diagnosis of temporomandibular disorders using infrared thermography, and the equipment used for temperature acquisition.

AUTHORS	POPULATION	CONTROL O COMPARADOR	RESULTADOS PRINCIPALES	EQUIPMENT
1. Barbosa et. al. 2019.[8]	TMD group (n = 45) Control group (n = 41)	RDC/TMD	Both groups, with and without TMD, presented mean absolute and non-dimensional temperature with no statistical differences.	FLIR T650
2. Canavan et. al. 1995. [9]	Control group (n=24) Group TMD (n=20)	RDC/TMD	Control group showed a high level of thermal symmetry. TMD group showed a low level of thermal symmetry with a T-value of 0.4°C.	Agema 870
3 de Lima et. al. 2022.[10]	Control group (n=78) Group TMD (n=37)	RDC/TMD y Fonseca questionnaire.	Feature extraction methods used by AI perform better than TI for TMD detection.	FLIR T650
4. Filho et. al. 2013. [6]	TMD (n = 52M) Control group (n = 52M)	RDC/TMD	No significant differences were observed.	FLIR T360
5. Gratt et. al. 1991.[11]	Control group (n=12) Group TMD (11)	Arthrotomographic examination	Half-face, quarter-face and TMJ measurements showed statistically significant differences in thermal symmetry.	Agema 870
6. Gratt et. al. 1996. [12]	Control group (n=70) Group TMD (n=70)	Clinical evaluation and arthrotomographic examination	Patients with pain and joint disorder showed increased temperature, TMJ control subjects had symmetrical (or “normal”) facial temperatures	Agema 870
7. Haddad et. al. 2014. [13]	Control group (n=30M) Group TMD (n=10M)	RDC/TMD	No statistically significant difference was observed	FLIR T400
8. Krzysztof y et. al. 2015. [14]	Control group (n=50) Group TMD (n=50)	Three-point anamnestic index of temporomandibular dysfunction (Ai)	The chewing test helped to slightly increase the diagnostic efficacy of thermography in identifying TMD patients.	FLIR TMSC500

9. McBeth y et. al. 1996 [15]	Control group (n=21) Orthodontic Group (n=18) Group TMD (n=20)	RDC/TMD	IT findings had a strong correlation with pain on muscle palpation.	Agema 870
10 Rytivaara et. al. 2021 [16]	Control group (n=21) Group TMD (n=19)	X-ray, cone beam computed tomography (CBCT) (RM)	T° after chewing were higher in TMD patients than in controls. For males, all calculated parameters demonstrated poor ability to discriminate TMD from controls.	FLIR T420
11 Rodriguez et. al. 2014 [17]	TMD (n = 52) Control group (n = 52)	RDC/TMD	Significant difference in skin T° between groups was only found in the measurement of left anterior temporalis muscle area.	FLIR T360,

During the search of the Cochrane Central Register of Controlled Trials we found the record of a randomized clinical RCT study belonging to Daniela Biasotto et al, 2018 (7) whose publication has not been made.

Controlled clinical studies making use of infrared thermography in the diagnosis of temporomandibular disorders

In the present review, the 11 clinical studies have as their main topic the use of infrared thermography in the diagnosis of temporomandibular disorders, of which all 11 included studies were controlled clinical studies and no publication of randomized clinical trials (RCT's) was found.

Table 1 presents the characteristics of the included studies: first author, journal and year of publication, additionally shows data based on P.I.C.O. strategy, and synthesis of the main conclusion(s) on the diagnosis of temporomandibular disorders using infrared thermography, and the equipment used to take the temperature.

During the search, 11 controlled clinical studies were found that reported on the use of infrared thermography in the diagnosis of temporomandibular disorders, all of them aimed at evaluating the diagnostic capacity of this technology. Six of the 11 selected studies made use of the Gold Standard as a comparator in the diagnosis of temporomandibular disorders or TMD, being the RDC/TMD [8, 9, 6, 13, 15, 17], other comparators were the arthrotomographic examination,[11] radiography and computed tomography,[16] artificial intelligence,[14] RDC/TMD combined with Fonseca questionnaire [10] and the combination of clinical evaluation with arthrotomographic examination.[12]

The 11 studies chosen were mainly distributed in South America with 48% [8, 10, 6, 13, 17] of which all the evidence was generated in Brazil, in North America 38% [9, 5, 12, 15] all originated in the United States, in Europe 14% [14, 16] where the first was performed in Poland and the second developed in Finland (Figure 2).

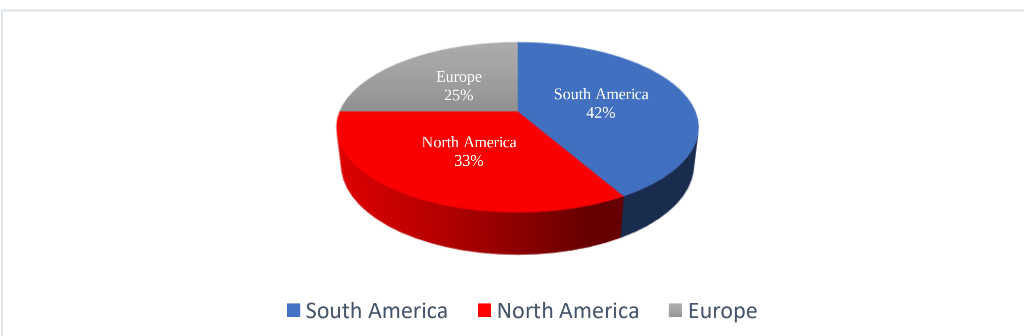

Figure 2. Studies incorporated worldwide.

Population evaluated in controlled clinical studies on the use of infrared thermography in the diagnosis of temporomandibular joint disorders.

The population evaluated in each study was variable in patients with temporomandibular disorders and control patients. The total temporomandibular joint disorder population evaluated in the 11 studies totaled 315 diseased patients, and the population of controls in the 11 studies totaled 378 cases of controls, the study with the largest population studied was Gratt et al. Dentomaxillofac. Radiol.,1996 [12] where they evaluated 70 patients with joint disorder conditions compared to a control group of 70 subjects.

Thermographic sensors used in controlled clinical studies on the use of infrared thermography in the diagnosis of temporomandibular joint disorders.

A high heterogeneity of the equipment used for temperature measurements was found, the most used thermographic camera was the Agema 870, which was used in 4 studies which are temporally located between 1991 and 1996 [9, 11, 12, 15] which correlate with each other since they have similar conclusions, indicating IT as a "promising" tool in the diagnosis of temporomandibular disorders.

Regarding the equipment used for temperature measurements, there is evidence of constant changes in their references over time, which are not due to a technological advance in relation to the current studies. Among the equipment used there are only 2 commercial brands, FLIR Systems® and Agema Thermovision®, whose second most used reference is FLIR T650 [8, 10] and FLIR T 360,[6, 17] in addition to FLIR T 400, [13] FLIR TMSC500 [14] and FLIR T420. [16]

Main findings and conclusions on the diagnostic effectiveness of infrared thermography in the diagnosis of temporomandibular joint disorders.

Seven studies concluded that infrared thermography shows promise as a diagnostic method or that it could become a complementary tool in the diagnosis of temporomandibular disorders. [9, 10, 11, 12, 12, 13, 15, 16] Four studies on the other hand concluded that infrared thermography has low accuracy and highly limited effectiveness and is therefore not an accurate tool for the diagnosis of TMDs. [8, 6, 14, 17] The conclusions of each study are listed in Table 3.

Of the selected studies, four studies did not report the sensitivity and specificity of the use of thermography. [8, 10, 12, 16] The seven additional studies that reported sensitivity and specificity values presented highly variable percentages, with sensitivity values ranging from 33% [17] to 92% [9] and specificity values ranging from 22.8% [6] to 95.5% (Table 2).

Gratt et al. [11] in 1991 reported a sensitivity of 86% and specificity of 78%, concluding that IT could be used as a diagnostic aid in the evaluation of internal dysfunction of the TMJ, later in 1996 he published a study [12] where he did not report values of sensitivity and specificity, The patients were distributed in 20 patients with acute TMJ trauma (mean ΔT=+0.5°C, ±0.3°C), 30 patients with internal TMJ misalignment (mean Δ = + 0.4°C, ±0.3°C), 30 patients with internal TMJ misalignment (mean Δ = + 0.4°C, ±0. 3°C) and 20 patients with TMJ osteoarthritis also reflecting increased temperature (mean ΔT= + 0.4°C, + 0.4°C) while the 70 control subjects presented symmetrical (or "normal") facial temperatures (mean = 0.2°C, ±0.1°C).

In 1995 Canavan et. al. [9] reported a sensitivity of 92% and specificity of 85% indicating that the control group showed a high level of thermal symmetry in the temporomandibular joint region while the group of TMJ patients showed a low level of thermal symmetry with an AT value of 0.4 ~ C, where they concluded that thermography shows promise as a diagnostic method for mild to moderate TMJ disorders.

In 1996, Mcbeth et. al. [15] reported values of 87% sensitivity and 86% specificity, concluding that IT findings have a strong correlation with pain on muscle palpation, indicating that IT shows promise as an objective tool for selecting normal subjects from subjects with TMD symptoms.
Subsequently between 1996 and 2012 no available studies were included that made use of IT in the diagnosis of TMD.

In 2013 Filho et. al. [6] reported highly variable and diffuse values of sensitivity ranging from 38.5% to 76.9%, and specificity ranging from 22.8% to 71.2%, thus concluding that infrared thermography of the masticatory muscles is not an accurate Instrument for the diagnosis of myogenic TMD.

In 2014 Rodriguez et. al. [17] and Haddad et. al. [13] evaluated thermography in the diagnosis of TMD, dividing the temperature shots into specific muscle regions as follows: In 2014 Rodriguez et. al. [17] evaluated the diagnostic ability of thermography comparing it with RDC/TMD in women, where they reported different values of sensitivity and specificity according to the muscle evaluated, in terms of sensitivity reported 33.5 % in left masseter, 41.8 % in right masseter, 42.6 % for left anterior temporal and 60.3 % for right anterior temporal muscle, in terms of specificity reported 67. 3 % in left masseter muscle, 55.8 % in right masseter, 48.4 % in left anterior temporalis and 41.8 % in right anterior temporalis muscle, concluding that none of the infrared thermography methods tested for the quantification of masseter and anterior temporalis muscles (area and extension analysis) agrees with the RDC/TMD for the diagnosis of myogenic TMD in women, i.e. it was not conclusive. In the same year Haddad et. al. [13] reported a sensitivity in masseter region of 70% and in anterior temporal region 80%, and a specificity in masseter region of 73% and in anterior temporal region of 62%, where he concluded that IT could be used as an aid in the complementary diagnosis of TMD.

Later in 2015 Krzysztof et. al. [14] performed different temperature measurements, one initial and one after a chewing test where he concluded a sensitivity of 44.3% before the chewing test and 46.4%, after the one of the chewing test, and a specificity percentage of 95, 5%, concluding that the evaluation of thermography has a diagnostic utility to identify patients with TMD with limited effectiveness, and that the chewing test helped to increase the diagnostic efficacy of thermography in the identification of patients with TMD.

4.4 *Main findings and conclusions on the diagnostic effectiveness of infrared thermography in the diagnosis of temporomandibular joint disorders according to the most recent studies.*

During the last 5 years three studies using infrared thermography in the diagnosis of temporomandibular disorders have been reported, [8,10, 16] which presented variable results, which were not reported in terms of sensitivity and specificity.

In 2019 Barbosa et. al. [8] conducted a clinical study with two groups, one composed of 45 control individuals and the other composed of 45 individuals diagnosed with temporomandibular joint disorders, making use of the Fonseca anamnestic index as a comparator, who evaluated by region the masseter, anterior temporal and TMJ muscle areas, and compared the values under the receiver operating characteristics curve to subsequently perform a Spearman correlation analysis (nonparametric data) between the level of pain and mean temperature, where they set the significance level at $p < 0.05$, who found that both groups presented absolute and non-dimensional mean temperature and no statistical differences, concluding that infrared thermography resulted in a low area under the curve, which hindered the differentiation of TMD through thermographic analysis, thus generating inconclusive results.

Later in 2021 Rytivaara et. al. [16] conducted a clinical study with two groups where one group was composed of 19 patients with a diagnosis of temporomandibular disorder and 21 control subjects, The overall temperatures were higher in men than in women and higher after chewing for the group of patients with temporomandibular disorders compared to the control group. Overall, there was a significant increase in all parameters after the first four minutes of chewing, but they did not increase significantly after the second chewing, which was performed after eight minutes.

The results in females statistically more significant were the thermal increase between the relaxed state and the state of the subjects after chewing for four minutes for the temporal (AUC: 0.72) and TMJ (AUC: 0.76) while in men, all calculated parameters showed poor ability to discriminate joints with disorders from controls; the study concluded that thermography could be a potential tool in the diagnosis of female patients with temporomandibular disorders.

Finally the most recent controlled clinical study that making use of infrared thermography with the aim of diagnosing temporomandibular disorders was published in 2022, where de Lima E et. al. [10] with the aim of evaluating three machine learning (ML) attribute extraction methods: Semantic radiomic association and radiomic-semantic association in the detection of temporomandibular disorder (TMD) using infrared thermography (IT), to determine which ML classifier, KNN, SVM and MLP, is the most efficient for this purpose, where the control population was composed of 37 individuals, and the population with temporomandibular disorders was composed of 41 individuals, making use of the Fonseca index and RDC/TMD to categorize patients, where lateral projections were acquired with thermography of each patient, selecting the masseter and temporalis muscles for attribute extraction where three attribute extraction methods were evaluated radiomic, semantic and radiomic-semantic association, and subsequently KNN, SVM and MLP classification algorithms were evaluated and making use of Hopkins, Shapiro-Wilk, ANOVA and Tukey statistical tests to evaluate the data, the significance level was set at 5% ($p < 0.05$). In the study results the training and test accuracy values differed statistically for the radiomic-semantic association ($p = 0.003$). MLP differed from the other classifiers for the radiomic-semantic association ($p = 0.004$). The accuracy, precision and sensitivity values for semantic and radiomic-semantic association differed statistically from radiomic features ($p = 0.008$, $p = 0.016$and $p= 0.013$), concluding that the use of artificial intelligence combined with infrared thermography presents promising results for the detection of temporomandibular disorders.

Table 3. Summary of the general conclusions of each study regarding the use of infrared thermography and its diagnostic capacity in the diagnosis of temporomandibular disorders.

STUDY	SENSIBILITY	SPECIFICITY
Barbosa y cols. Dentomaxillofacial Radiology. 2019.	Does not report	Does not report
Canavan y cols. Oral surgery, Oral medicine, Oral pathology, Oral Radiology, and Endodontology. 1995.	92%	85%
de Lima et al. Dentomaxillofacial Radiology. 2022.	Does not report	Does not report
Filho et al. Journal of Manipulative and Physiological Therapeutics. 2013	Between 38,5% y el 76,9%	Between 22,8% y el 71,2%,
Gratt y cols. Oral Surg Oral Med Oral Pathol. 1991.	86%	78%.
Gratt y cols. Dentomaxillofacial. Radiol..1996	Does not report	Does not report
Haddad et al. Dentomaxillofacial Radiology. 2014.	Masseter region:70% Anterior temporal region: 80%	Masseter region:: 73% Anterior temporal region: 62%,.
Krzysztof et al. Medical Science Monitor. 2015.	44.3%, before the chewing test, and 46.4%, after the chewing test	95,5%
Mcbeth et al. American Journal of Orthodontics and Dentofacial Orthopedics. 1996	87%.	86%.
Rytivaara et al. The Journal of Craniomandibular & Sleep Practice. 2021	Does not report	Does not report

Rodriguez et al. Journal of Bodywork Movement Therapies. 2014	LM: left masseter: 33.5 % RM: right masseter: 41.8 % LT: left anterior temporal: 42.6 % RT: anterior right temporal: 60.3 %	LM: left masseter:67.3 % RM: right masseter: 55.8 % LT: left anterior temporal: 48.4 % RT: anterior right temporal: 41.8 %

DISCUSSION

Temperature changes have been considered signs of disease and have been quantified for centuries to evaluate them, a practice that was recorded in the year 400 BC where Hippocrates judged the temperature to assess patients affected by a disease.[18] where Hippocrates judged the temperature to assess patients affected by a disease,[18] which over the years has allowed some technological development of multiple tools whose objective is the quantification of body temperatures, in order to identify the different pathologies or states of health of individuals, such is the objective of the use of infrared thermography in medicine, which has been widely used in different pathologies since 1960 in pathologies such as arthritis,[19] multiple inflammatory and degenerative joint diseases,[20] proliferation and involution of infantile hemangiomas,[21] breast cancer,[22] hepatic fibrosis,[23] among many others, since it represents multiple advantages as it is a relatively inexpensive, non-ionizing and non-invasive technology, so that it has been evaluated in multiple studies whose objective is to measure its diagnostic capacity in temporomandibular joint disorders.

The first reported controlled clinical study was conducted by Gratt et al. [11] in 1991 where it was suggested that infrared thermography could be considered as a diagnostic aid in the evaluation of internal TMJ dysfunction, thus generating the first evidence of the use of this technology for the purpose of diagnosing temporomandibular disorders, This study evaluated the internal disorders of the TMJ and the study population was composed of 11 patients with internal disorder and 12 normal patients, which can be considered a low sample size of individuals evaluated, additionally the thermography was performed with an infrared thermographic unit whose thermal sensitivity ranged between 1. O" and 0. 5" C, making it an unspecific equipment, since the changes generated are subtle and the range of error can be considered high, the study reported sensitivity of 86% (+ 7.8%) and specificity, 784 (It 7.1%) and the results of objective measurements of the thermal symmetry of the TMJ region was in normal subjects of 89.3% (+3.0%); patients with internal disorder of 66.1% (+16.2%); t21 = -4.89, p < 0.01, later in the year 1996 the same author [12] in a blinded controlled clinical study at 0.1 °C thermal accuracy, applied a novel thermal classification system classifying it as : "normal" when the Δ zone was 0.0 to ± 0.25°C, 'hot' when the Δ zone was > + 0.35°C, 'cold' when the zone was < - 0.35°C, and 'equivocal' when the Δ zone was + (0.26-0.35)°C, The study consisted of 164 different dental patients mainly with diagnostic problems and 164 matched (control) patients of which 70 were considered to have temporomandibular disorders and 70 controls, showing an increase in temperature over the most affected region and symmetrical facial temperatures in patients considered to be healthy.

Additionally, the literature under study faces a disparity in terms of temperature acquisition because different sensors have been used, which have different characteristics and thermal sensitivity, which generates heterogeneity of the overall results, additionally most of the sensors used have been created with different objectives than the temperature acquisition in medical or scientific terms, and rather have been manufactured with requirements of large modern engineering industries.

The main limitation of infrared thermography in the diagnosis of temporomandibular disorders could be its ability to quantify the surface temperature of the bodies, which makes it difficult to record the ideal temperature of the affected area because it must face different percentages of subcutaneous fat.

Currently, and taking into account the study conducted by de Lima E et al. in 2022, important future prospects arise, since this study generated evidence of a combined use of infrared thermography and artificial intelligence, which could generate autonomous learning of interpretation of results guided by artificial intelligence.

CONCLUSIONS

Although most of the studies evaluated have concluded that thermography is a promising technology in the diagnosis of temporomandibular joint disorders, the literature is highly variable in terms of the reliability of the use of this instrument for the diagnosis of temporomandibular disorders, which is reflected in sensitivity and specificity values with widely marked differential ranges. This is due to the ability of thermography to capture temperatures on external surfaces while the disorders are generated under multiple surfaces and anatomical tissues, thus generating a possible limitation in their recording. Additionally, studies with larger sample sizes are required, with long-term evidence and measurements that obey standardized protocols avoiding factors that generate variability in the body temperature of individuals.

DECLARATION OF CONFLICTS OF INTEREST

There is no conflict of interest in relation to this study.

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The study expenses were self-financed by the authors.

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