

# Thermography Applied to the Evaluation of Inflammatory Response After Third Molar Teeth Removal: A Systematic Review

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## Abstract

Surgical removal of third molar teeth is a usual procedure in dental services and causes mechanical trauma. The study aimed to evaluate the use of thermography as an instrument to monitor the inflammatory signs after surgical removal of third molar teeth. This systematic review was done according to PRISMA 2020 recommendation. The research was done from January 1st., 1985 to March 31st., 2020 using as database: Medline/Pubmed, Web of Science, Embase, Scopus, and Scielo. The inclusion criteria were studies that analyze post-surgical evolution after third molar teeth removal using thermography as one of the methods, both genders and aged between 16 and 44 years. Methodological quality and risk of bias were evaluated according to the Cochrane scale ACROBAT-NRSI. This systematic review recognized 5 studies using thermography as a tridimensional analysis tool for local dermal inflammatory response after surgical removal of third molar teeth. The results presented by the studies here strongly suggest thermography as an important evaluation tool for circulatory alterations that integrate the inflammatory and healing process after third molar teeth removal surgeries and a complement to the post-surgical monitoring process, bringing important information concerning the general health state of patients submitted to these procedures.

**Keywords:** Third molar; Inflammatory response; Dentistry.

## Resumo

A remoção cirúrgica dos terceiros molares é um procedimento comum nos serviços odontológicos e causa traumas mecânicos. O estudo teve como objetivo avaliar o uso da termografia como instrumento de monitoramento dos sinais inflamatórios após exodontias cirúrgicas de terceiros molares. Esta revisão sistemática foi feita de acordo com a recomendação PRISMA 2020. A pesquisa foi realizada no período de 1º de janeiro de 1985 a 31 de março de 2020, utilizando como base de dados: Medline/Pubmed, Web of Science, Embase, Scopus e Scielo. Os critérios de inclusão foram estudos que analisaram a evolução pós-cirúrgica após exodontia de terceiros molares utilizando a termografia como um dos métodos, ambos os sexos e com idade entre 16 e 44 anos. A qualidade metodológica e o risco de viés foram avaliados de acordo com a escala Cochrane ACROBAT-NRSI. Esta revisão sistemática reconheceu 5 estudos usando a termografia como uma ferramenta de análise tridimensional para a resposta inflamatória dérmica local após a remoção cirúrgica dos terceiros molares. Os resultados apresentados pelos estudos aqui incluídos sugerem fortemente a termografia como uma importante ferramenta de avaliação das alterações circulatórias que integram o processo inflamatório e cicatricial após cirurgias de remoção de terceiros molares e um complemento ao processo de acompanhamento pós-cirúrgico, trazendo informações importantes sobre a saúde geral estado dos pacientes submetidos a esses procedimentos.

**Palavras chaves:** Terceiro molar; resposta inflamatória; Odontologia.

**DOI:** <http://dx.doi.org/10.18073/pajmt.2023.10.006>

## INTRODUCTION

The inflammatory response that causes these symptoms is part of the defense work of the organism when submitted to tissue damage and has a protective feature (1,2). The medication protocols for anti-inflammatory items are meant to reduce the aggravation of this inflammatory process (3,4).

The first steps of the cicatrization process are extremely important for the procedure to succeed. The patient must follow all the instructions given by the dental surgeon, including resting, cryotherapy, pasty food, and the scheduled use of all prescribed medication, but post-surgical attendance is mandatory to grant safer and more comfortable stages of cicatrization for the patient (5,6).

Some indicators are used for post-surgical control of enclosed third molar teeth extraction, amongst them the measuring of the maximum mouth opening to quantify the post-surgery trismus, performed with the use of graduated rulers to obtain the interincisal distance; a facebow is also used for edema measuring and a Visual Analogue Scale (VAS) can also quantify the level of pain during the inflammatory process (2).

Infrared thermography is an imaging exam present in the health area's scope of diagnosis, evolutionary monitoring, and prognosis. Scientific research shows that this exam is accurate and reliable as a tool in diagnosis, according to the theory of the musculoskeletal system, which claims that structures must be in thermal equilibrium and symmetric when in a healthy state (7-9). Although dentistry already uses thermography, the subareas in dental treatments where this tool could benefit diagnosis/monitoring are still unclear (7,9). Besides, this field's research centers/authors and journals are not yet formally established. Therefore, the objective of this study was to evaluate the use of thermography as an instrument to monitor the inflammatory signs after surgical removal of third molar teeth.

## METHODOLOGY

### Protocol and Search Strategy

This systematic review was made according to PRISMA recommendation (10). The research was done from January 1st., 1985 to March 31st., 2020 using as database: the National Medicine library (Medline/ Web of Science, Embase, Scopus, and Scielo).

Search words found in medical publication titles (MESH) or frequently used words in related articles were used in this research: ("Thermography" OR "Temperature Mapping" OR "Mapping, Temperature" OR "Mappings, Temperature" OR "Temperature Mappings" OR "Skin Temperature" OR "Skin Temperatures" OR "Temperature, Skin" OR "Temperatures, Skin" OR "Skin thermal" OR "Infrared imaging" OR "Infrared thermography" OR "Infrared Camera" OR "Thermographic pictures" OR "Thermographic images" OR "Thermographic imaging" OR "Thermal images" OR "Thermal image" OR "Thermal imagers" OR "Thermal imaging") AND ("General practice, dental" OR "Dental General Practices" OR "Dentistry" OR "Medicine, Oral" OR "Oral and Maxillofacial Pathology" OR "Neoplasms, Oral" OR "Fever Blister" OR "Temporomandibular joint dysfunction syndrome" OR "Temporomandibular joint disorders" OR "Facial Pain, Neuralgic" OR "Maxillofacial Surgery" OR "Paresthesias" OR "Endodontology" OR "Dental Pulp Necroses" OR "Odontalgia" OR "Odontalgias" OR "Periodontic" OR "Periodontal Disease" OR "Salivary Gland Diseases" OR "dental implant" OR "Geriatric Dentistry" OR "Forensic Dentistry" OR "Pediatric Dentistry" OR "Orthodontics" OR "Dental Prosthesis" OR "impacted third molar", OR "third molar extraction"). Besides that, bibliographic references from other sources were also explored in search of studies that might not have been tracked in the main database.

### Inclusion and Exclusion criteria

The systematic review here presented included studies that fulfilled the following inclusion criteria (11): Studies that analyze

post-surgical evolution after third molar teeth removal using thermography as one of the methods, both genders and aged between 16 and 44 years. Procedure details, the period of post-surgical attendance, and the use of preoperative medication were also considered.

**Selection of Studies**

Two evaluators selected the studies, and another was responsible for keeping track of discrepancies in every revision step. Studies that showed no relevant context for the target of the research and those that did not include the use of thermal images as a collecting tool for the analysis – as well as publications that were not revised by pairs – were all excluded from this review.

**Data collecting process**

The following data were extracted from the studies: gender and age of the study specimen, surgical procedure characteristic details, period of post-surgical attendance, preoperative medication prescribed and used, instruments that were used to evaluate the inflammatory response after the surgery.

**Methodological quality and risk of bias**

Methodological quality and risk of bias were evaluated according to the Cochrane scale ACROBAT-NRSI. The tool evaluates

seven domains: 1) confusion; 2) selection of participants in the study; 3) intervention measure; 4) not receiving the attributed intervention; 5) losses; 6) quantifying the results; 7) selective report of results. The first three domains refer to pre-intervention and the other four are post-intervention. To each domain, the evaluations are assigned: “Low”, “Moderate”, “Severe”, “Critical”, and “No information”. The general risk of bias for each study is the domain with the highest risk of bias (Table 1)(12).

**RESULTS**

Figure 1 presents the flow chart of the studies included in this systematic review. A total of 115 studies were traced by other methods. From those, a total of 32 studies were traced for analysis. Then, 24 studies were excluded by content, 3 were duplicated, and one systematic review, so 4 remained for analysis. One article was later included through a cross-reference search, performing a total of 5 articles for evaluation.

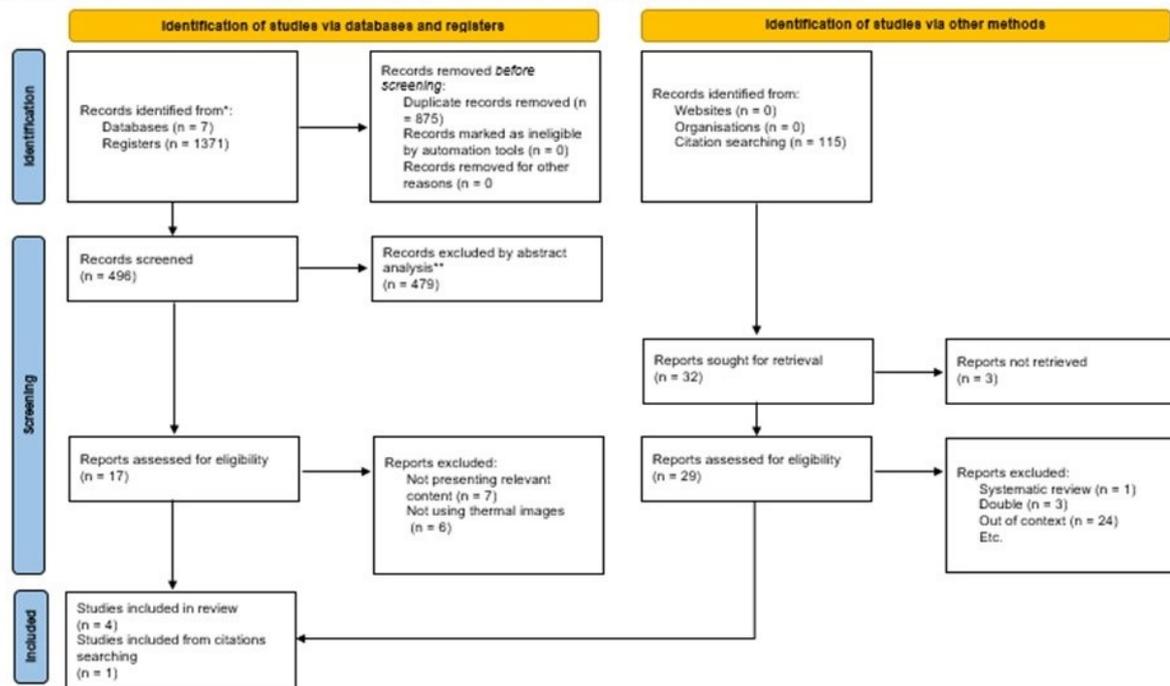
Table 1 displays the selected studies' methodological quality and risk of analysis bias. The main sources of bias were related to pre-operation and sampling stages, like volunteers not properly prepared for the thermography process and the absence of room temperature control where thermal images were collected, thus creating a confusion bias in sampling test results.

**Table 1.** Methodological quality and risk of bias in the selected studies

Study	Preoperative		During operation	Postoperative				Risk
	1	2	3	4	5	6	7	
Skjelbred P.1983 (13)	High	Low	Low	Low	Low	Low	Low	High
Ventã I. 2001 (14)	Low	Low	Low	Low	Low	Low	Low	Low
Christensen J. 2012 (15)	Low	Low	Low	Low	Low	Low	Low	Low
Christensen J. 2014 (16)	Low	Low	Low	Low	Low	Low	Low	Low
Pedreira A. 2016 (17)	Low	Low	Moderate	Low	Low	Low	Low	Moderate

**Legend:** 1) confusion; 2) selection of participants in the study; 3) intervention measure; 4) not receiving the attributed intervention; 5) losses; 6) quantifying the results; 7) selective report of results.

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources



**Figure 1.** Flow chart of studies included in the systematic review.

Table 2 shows the results offered by the analyzed studies. The first one (13) refers to an identical crossed and controlled study with six patients who had used corticosteroids before the surgical procedures. There was pain reduction evaluated through VAS, edema, and trismus. The local temperature, measured from the facial area, was lower in patients who had taken corticosteroids compared to those patients who had not used that medication. In the second study (14), thermography was used on the first and the seventh day after the surgical procedure, showing a temperature reduction with the use of anti-inflammatory

medication. In the third clinical study (15), the temperature was taken on the second post-surgery day e showed a slight reduction compared to the results obtained before surgery without using corticosteroid either before or after the procedure. The fourth one (16) was a cross-random study where one group of patients received corticosteroids and the other group took just the placebo. Dermal thermography performed in the facial area was used to evaluate circulatory changes. The temperature difference was slightly higher in the placebo group than in the corticosteroid group but without statistical significance (P=0,09).

**Table 2.** Results of the analyzed studies

Reference	Skjelbred P. (13)	Ventä I. (14)	Christensen J (15)	Christensen J. (16)	Pedreira A. (17)
<b>Nr /Gender /Age-group</b>	6 / W and M / 19 - 22	30 / W and M / 18-39	127 / W and M/ 18-44	124/ W and M/ 18 – 25	24/ W and M/ 16 – 39
<b>Procedure details / Monitoring period</b>	Third molar teeth / 7 days	Impacted third molar teeth / 7 days	Third molar teeth / 7 days	Third molar teeth / 7 days	Third molar teeth / 7 days
<b>corticosteroid 1 (Via adm)</b>	Methylprednisolone 40g (IV)+Naloxone after 2h	150mg (PO) or 100mg (PO) + 50mg (IM)	Not used	Methylprednisolone 32mg (PO)	Dexamethasone 8mg (PO)
<b>corticosteroid 2 (Via adm)</b>	Placebo	Placebo	Not used	Placebo	Not used
<b>Evaluation tool edema / Result Corticosteroid 1 / Result Corticosteroid 2 / Result value Control</b>	(day3)Measuring Tape / G1: 19mm /G2: 35mm p= 0,06	Not used	Not used	(day2)VAS / G1: 11,2 mm / G2: 26,1mm / p=0,07	(day3)Measuring Tape / G1: 12,1mm/G2: 11,7mm/G3:1 1,9mm/G4:12 ,1mm/P 0,630
<b>Evaluation tool trismus / Result Corticosteroid 1 / Result Corticosteroid 2 / Result value Control</b>	(day3)Not informed / G1:18%/G2: 34%/P=0,04	Not used	Not used	Not used	(day3)Caliper Rule /G1: 4,0mm/G2: 4,5mm/G3: 2,8mm/G4:2, 9mm/ P 0,197
<b>Evaluation tool pain / Result Corticosteroid 1 / Result Corticosteroid 2 / Result value Control</b>	(day3)Nr pills / G1: 0/G2:0	Not used	Not used	Not used	Analogical Visual Scale (day3)/G1:1/ G2:0/G3:2/G 4:2,5/ P0,975
<b>Evaluation tool temperature / Result Corticosteroid 1 / Result Corticosteroid 2 / Result value Control</b>	(day3)Not informed / 0,4° /0,9°/ p> 0,10	(day1) No-vaTherm / G1: 0,8° / G2:1,6° / p< .001	Flir Therma-Cam E320 / 32,39° / 32,06° / p:< 0,001	(day2)Therma-Cam E320 / 32,3° / 32,2°/P= 0.9	PO+la-ser/29/42° 15min PO / G4: 33,94°Preop/ 33,66°PO/33, 40 PO + la-ser / 33,50 15min PO P 0,26/0,14/,02 1/0,16

Legend: Adm: Administration; G1: Group 1; G2: Group 2; G3: Group 3; G4: Group 4; IV: Intravenous; IM: Intramuscularly; Pre op: Preoperative; PO: Postoperative; W: Woman; M: Man.

The last study (17) presented in Table 2 was a random clinically controlled blind study that checked the effectiveness of 808nm aluminum and gallium infrared laser used after third molar teeth extraction, analyzed by thermal images that showed that the laser was able to alter local circulation although had not significantly changed swelling, pain or trismus.

## DISCUSSION

This systematic review recognized five studies using thermography as a tridimensional analysis tool for local dermal inflammatory response after surgical removal of third molar teeth. Thermography has considerably evolved through the years, especially concerning the sensitivity of electronic components and the improvement in image interpretation, legitimating the importance of reassessing its use as an instrument for physiological analysis in dentistry areas of interest. Some studies revealed a risk of bias during the surgical operation because there was no information concerning the position of the patient, camera distance, and position (18). Besides that, the division of groups showing differently positioned third molar teeth to be removed may affect the chosen operation procedures and, as a result, the inflammatory response (19).

The infrared thermography test is quite favorable because it can provide real-time tissue analysis, is a non-invasive and non-ionizing method, and has a relatively low cost of acquisition and maintenance. The inflamed tissue releases heat, so thermography is rather promising to make the analysis of inflammatory response possible in third-molar teeth extraction surgeries (14,20).

Patients with nerve damage after dental surgeries, besides being diagnosed with syndromes such as Frey's, also presented skin temperature changes thus reinforcing the benefits of using thermography both in diagnosis and dental treatments (21,22).

Specifically, when referring to third molar teeth drawing surgeries the post-operative monitoring process is important to grant

patient safety and to reduce all side effects that may bring some trouble to the patient's daily routine after the procedure and then help patients to have their life quality back (23). It is important to carefully analyze critical signals and symptoms the patients report.

The main restriction of thermography is the precision loss when detecting temperature changes related to different distances from the body surface. Besides that, some tissue peculiarities may reduce the temperature reading precision, such as the presence of adipose tissue and saliva, which can limit or even make it impossible to analyze thermal images (24,25).

Most of the studies evaluated in this review showed changes in skin surface temperature during the post-surgery monitoring process when comparing groups that used medication to the ones that used placebo in preparation for the procedure, and the medicated ones presented lower regional face temperatures and revealing a more controlled inflammatory response as compared to the ones that were not medicated.

This shows a significant influence in surgery planning. It is well known that the use of corticosteroids is widely indicated prior to third molar teeth removals (4-6,25). However, thermography is an important tool to analyze the differences between corticosteroids and prescribed amounts that may be more effective for inflammatory control – still with some lack of literature, as mentioned in other systematic reviews (9,26).

Thermal images have also demonstrated that low-intensity laser applied to the operated skin surface instantly reduces the temperature, managing the inflammatory response right after the surgical procedure.

Surgery for third molar teeth removal has well-defined clinical indications for prevention and maintenance of buccal health. It is one of the most representative concerning post-surgical acute pain and inflammation (27), and the cautious attendance during the first seven days after the intervention, along with the attention that the patient must be oriented to take in that period,

is substantial for a good clinical evolution after the surgery (3). Clinical conditions evaluation tools that confirm the inflammatory response are routinely used to compare the postoperative improvement: the measure of the maximum mouth opening, trismus presence and interincisal distance with a graduated scale, edema evaluation with caliper rules, facebows or measuring tapes, using facial reference marks and pain visual scales to quantify the patients' level of pain during the healing process (13,17). Thermography has been used in studies as a complementary tool in the inflammatory response evaluation and it is the only examination that can provide local microcirculatory physiological assessment (28), charting changes in real-time and allowing comparative temperature records of inflamed tissues as another option to make it safer to monitor the evolution of third molar teeth surgeries (13-15).

The studies included were relevant regarding image acquisition and evaluation standards.

All articles reported in the literature presented the selection of lower molar teeth where the evaluation ROI was defined in the lower third part of the face, thus corresponding to the mandibular region. Skjelbred (13), stated that day three after the operation revealed temperature differences between operated and non-operated sides, 0.4 Celsius degrees after steroid and 0.9 Celsius degrees after the second surgical procedure, without the use of corticosteroid. Studies of Venta (14) and Christensen (15) give support to the findings of Skjelbred (13) when the use of pre-surgical corticosteroid ( $dT=0.8^{\circ}$ ;  $dT=0.21^{\circ}$ ;  $dT=0.21^{\circ}$  Celsius degrees) respectively resulted in lower facial temperatures in the first days after procedure as compared to the ones registered in volunteers that had taken placebo ( $dT=1.6^{\circ}$ ;  $dT=0.36^{\circ}$ ;  $dT=0.39^{\circ}$  Celsius degrees). Pedreira *et al.* (17) studied four groups of volunteers according to their type of surgical procedure (broken and unerupted teeth) and post-operation treatment (laser therapy); Dexamethasone 8mg was prescribed prior to surgery and no post-operation medication was used other than Dipyrone 500mg in cases of extreme pain.

The laser was used after surgery for seven post-operation alternate days in 2J pre-audicular (E1), second superior molar area (E2), and mandibular angle (E3).

## CONCLUSION

The results presented by the studies here included strongly suggest thermography as an important evaluation tool for circulatory alterations that integrate the inflammatory and healing process after third molar teeth removal surgeries and a complement to the post-surgical monitoring process, bringing important information concerning the general health state of patients submitted to these procedures.

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