Clinical evaluation of thermography as a diagnostic tool in oral and maxillo-facial lesions

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ABSTRACT

Objectives: To evaluate the use of thermography in diagnosing dental abscesses and cellulitis of odontogenic origin, and to determine whether changes in heat emitted from a dental abscess and cellulitis are different and implementing these results in future studies related to dental thermography as a diagnostic tool in dental clinics.

Methods: This study was performed on 48 adult patients seen at the Department of Conservative Dentistry of Royal Medical Services suspected to have either facial cellulitis or a dental abscess. Thermal images of affected and unaffected skin were obtained for each patient. A provisionaldiagnosis was madeon the basis ofclinical examination alone and clinical examination plus thermography. A definitive diagnosis of the abscess was made when the incision for drainage revealed the presence of pus. Temperature difference was calculated between the affected and the corresponding contra-lateral regions of interest.

Results: A definitive diagnosis of facial cellulitis was made in 50%, and dental abscesses in 50% of the cases. A correct diagnosis was made 87.5% of the time using the clinical examination alone, while clinical examination with thermography increased the correct diagnosis to 95.8% of the cases.In males, no significant temperature differences between affected and contralateral unaffected site in facial cellulitis and dental abscess patients were recorded (2.1 versus 1.68 °C, P =0.4930). While temperature differences were greater in facial cellulitis patients than in dental abscess patients in females (2.84 versus 0.92 °C, P =0.0016).

Conclusion: Thermography can be used as an adjunct for making correct diagnosisdifferentiating between facial cellulitis and dental.Heat emitted from a dental abscess and cellulitis was different in males' and females.

Keywords: Abscess, Cellulites, Thermography

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Introduction

An abscess is a localized collection of pus in a cavity formed by the disintegration of tissues. The expanding lesion can spread through the soft tissue causing cellulitis.[1] The pyogenic oro-facial infections are most commonly odontogenic in origin, ranging from periapical abscesses to superficial and deep infections in the neck.[2] The most common type of dental abscess is a periapical abscess. The dental infections are usually self-limiting but serious complications requiring immediate hospitalization may develop, such as facial cellulitis, mediastinitis, brain abscess, septicemia and thromboembolism.[3-5] Hence, early recognition of infections and proper management is essential as untreateddental abscesses can progress into cellulitis, resulting in diffuse inflammation of soft tissue spaces.[6]

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The symptoms and signs of cellulitis include skin erythema, edema, and warmth of the affected area. An abscess is suspected on physical examination when a tender, fluctuant area is palpated within this area of cellulitis.[7, 8] It has been suggested in the literature that the use of ultrasound may aid in differentiating between cellulitis and an abscess of odontogenic origins.[9] The treatment of an abscess includes incision and drainage. If cellulitis is diagnosed, antibiotic regimens are usually effective; but in severe cases, however, may require hospitalization and intravenous antibiotics. Clinically, it is essential to distinguish between odontogenic facial cellulitis and an abscess in order to properly diagnose and treat dental-related infections early and effectively and to spare patients with cellulitis an invasive procedure that can cause significant anxiety and discomfort.[8]

Thermographic cameras generate images based on the amount of heat dissipated from the human skin surface in the form of electromagnetic radiation. Thermography is considered a noninvasive method for measuring physiologic and pathologic changes in body surface temperature in many conditions, such as infection and inflammation.[10,11] Thermography is easy, quick to use, well tolerated by patients, non-irradiating and provides objective data about the tissue below the skin, providing a more accurate method for localizing the infection rather than the subjective palpation method.[12,13] The most commonly used types of thermography devices are liquid crystal sheets that are placed directly on the skin, infrared cameras (also called digital infra-red thermal imaging(DITI), and temperature gradient studies.[14] The purpose of this study was to determine the use of thermography for diagnosing dental abscesses and cellulitis of odontogenicorigin and to evaluate whether changes in heat emitted from a dental abscess and cellulitisaredifferent.

Methods

This study was performed on 48 adult patients (15 females, 33 males, mean age 32.88, range 19-69 years) seen at the Department of Conservative Dentistry of Royal Medical Services suspected to have either facial cellulitis or a dental abscess. Written informed consent was taken for each case, and the procedure was explained to the patients. The research was approved by the Ethics Committee of King Hussein Medical Center according to the ethical principles of Helsinki Declaration. Baselines data including age and gender were recorded for all participants. All patients underwent triple assessment including clinical examination, radiological (Orthopantograms) and laboratory examination (CBC).

The exclusion criteria were applied to avoid any internal and external effect of heat on examined patientsincluding: depressive disorders, pain in other parts of the body, inflammations, taking painkillers and anti-depressants, periodontal diseases and completed treatment of masticatory motor system dysfunctions.

Each patient was examined and diagnosed by two examining dentists. A provisional clinical diagnosis was givenaccording to clinical examination alone and a second clinical examination with thermography was made. A definitive diagnosis of the abscess was recorded when the incision for drainage revealed presence of pus. Digital infrared images were captured from infected and corresponding contra-lateral regions of interest using FLIR® C2 imaging camera (FLIR Systems ThermaCAMQuickReport 1.1, Precisions Teknik AB).The circulation of blood in the face causes tiny color changes on facial images that are undetectable with the human eye.

The FLIR infra-red thermal (IRT) system integrates a CMOS camera with thermography to capture visible and thermal images including MSX® (Multi-Spectral Dynamic Imaging) real-time thermal image enhancement with high sensitivity (<0.10°C). The visible and thermal images were recorded at a resolution of 4,800 measurement pixels. The CMOS camera uses this information to determine temperature difference. The spectrum of colors indicates an increase or decrease in the amount of infrared radiation being emitted from the body surface. Thermal sensitivity of 0.1 u℃ per color tone was used, based on a rainbow-type colorimetric scale (color palette), in which the colors were, from hottest to coldest: white, pink, red, orange, yellow, light green, dark green, light blue, dark blue, purple and black. The colors indirectly indicated the degree of distribution of local cutaneous blood perfusion.Since there was no universal standard for thermal imaging in the facial region and to ensure reproducible environmental conditions and to prevent exogenous temperature changes, all patients underwent the same thermographic protocol based on The American Academy of Thermology (AAT) 2015 v2 and the medical infrared imaging guidelines outlined by Ring and Ammer [15]including:

1. The examining physician explains the dental/systemic health necessity for performing infrared Dental/Systemic Health Imaging.

2. Responds to questions and concerns about any aspect of the examination.

3. Obtaining a complete, pertinent history by interview and/or review of the patient's dental/medical record.
4. The patient should not have contact with anyobjects if that body part is being imaged. No clothing or garments should be worn over any region that is under study.
5. Shower or bath the morning of the test to ensure that the skin is as clean as possible.
6. Avoid placing any material of any kind on the skin, such as any skin lotions, deodorants, preparations, moisturizers, liniments, makeup, hair spray, hair cream, topical analgesics, etc.
7. Nicotine discontinued four hours prior to imaging and no drinking hot or cold water 10 to 15 minutes prior to measurement.
8. Control for the distance between the subject and camera (~1m).
9. Room temperature (23-24°C) (was recorded using a mercury thermometer).
10. The absence of direct solar or electric lighting and heaters.
11. Adaptation time (Subjects were asked to remain in sitting position for approximately 15 minutes prior to imaging. During this adaptation process, the patients did not undertake any physical activity, chew or touch their facial skin).
12. Room area (~15 m2).
13. Relative humidity of 50–70%.

The region of interest (ROI) was recorded from two different views (right and left views) of the face with thermal and digital photographs.All images were saved with a resolution of 320x240 pixels and were processed using the software provided by the manufacturer of the camera (FLIR® Tools+ v6.4). The thermograms depicted the subject's face and the surroundings in different colors according to temperature (figure 1).

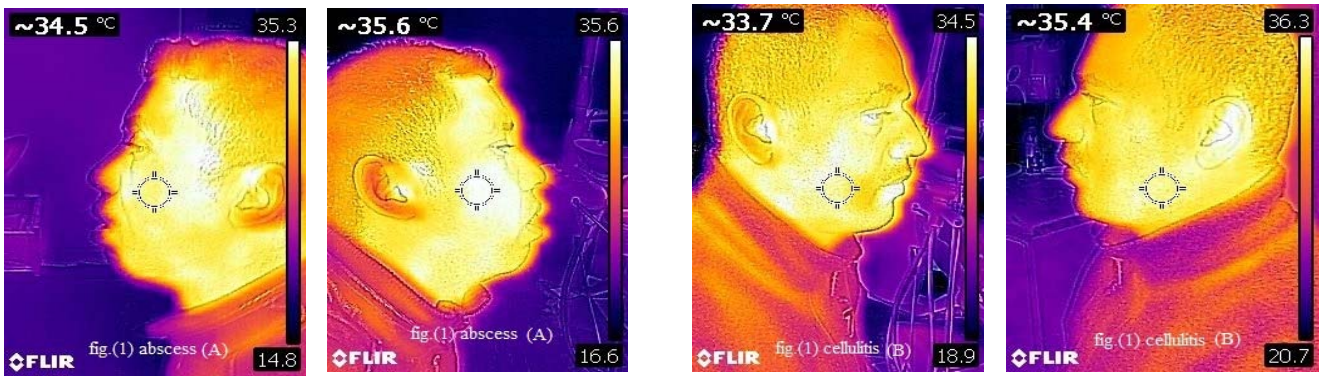

Fig 1: Thermograms of a dental abscess (A) and facial cellulitis (B).

Statistical analysis:The data were entered into a spreadsheet and analyzed using the IBM SPSS Statistics for Windows, version 19 (IBM Corp, Armonk, NY, USA). The means (± standard deviation) and ranges were all calculated. Differences of continuous variables between two independent groups were assessed with the 2-tailed t-test. The significance threshold was set at 0.05.

Results

Of the 48 cases examined, 21 cases were diagnosed with cellulitis and 27 cases with a dental abscess using the clinical examination alone. Twenty-three cases were diagnosed with cellulitis and 25 cases were diagnosed with a dental abscess using the clinical examination plus thermography. A definitive diagnosis of a dental abscess was made when pus came out upon drainage in 50% of the cases (24 cases) and facial cellulitis in 50% of the cases (24 cases). A correct diagnosis was made 87.5% of the time using the clinical examination alone, while clinical examination with thermography increased the correct diagnosis to 95.8% of the cases. Temperature differences between affected and contralateral unaffected sites were greater in facial cellulitis patients (2.4 °C) than in dental abscess patients (1.49 °C) (P = 0.0485).Thermograms of a dental abscess and facial cellulitis are shown in (Figure 1).To evaluate whether changes in heat emitted from a dental abscess and cellulitis are different between genders, the patients were divided

into two groups according to gender. In the male group, there were no significant temperature differences between the affected and contralateral unaffected sites in facial cellulitis and dental abscess patients (2.1 versus 1.68 °C, P =0.4930). While temperature differences were greater in facial cellulitis patients than in dental abscess patients in females only (2.84 versus 0.92 °C, P =0.0016) (Table I).

Table I: Temperature difference between affected and contra lateral unaffected side (in Celsius).

	Age (±SD)	Abscess (N)	ΔT (±SD)	Cellulitis (N)	ΔT (±SD)	*P value*[*]
All	32.88 (±10.7)	24	1.49 (±1.0)	24	2.4 (±1.9)	0.0485
Range	19-69		0.2-4.5		0.6-9.5	
Female	36.73 (±13.4)	6	0.92 (±0.6)	9	2.84 (±1.1)	0.0016
Range	21-69		0.2-1.6		1.4-4.6	
Male	31.12 (±8.9)	18	1.68 (±1.1)	15	2.1 (±2.2)	0.4930
Range	19-55		0.3-4.5		0.6-9.5	

[*]Two-tailed t-test

Discussion

Human skin is very sensitive to infrared radiation, and is remarkably good absorber and emitter of infrared radiation, having an emissivity of 0.97 in the infrared spectrum.[16] Planck's radiation law, a mathematical relationship formulated in 1900 by German physicist Max Planck to explain the spectral-energy distribution of radiation emitted by a blackbody. According to Planck's law, the electromagnetic radiation from the skin surface is a reflection of heat generation from below the surface.[12,17] Imaging and quantification of surface body temperature provide an indirect measure of the microcirculation in a particular area, and assists in assessing disease activity and monitoring treatment response.[13] Thermography has been used for more than 50 years in medicine.[13] Most of the previous studies were performed to detect pathologies such as peripheral nerve injuries [18-20] or Temporomandibular Joint Disorders.[21]

Thermography is an excellent mean to visualize soft tissue infection in humans and can provide a physiologic indicator of underlying disease.[8] Thermography depends on the fact that inflammation causes the body to produce heat. A temperature difference greater than +3°C is suggestive of infection.[22,23]

However, interpretation of the thermographic image has been troubled by subjectivity.[24] In this study, we aimed to quantify the heat associated with a dental abscess and facial cellulitis, in an attempt to investigate the suitability and the sensitivity of the thermal imaging technique in dentistry as an adjunct tool to differentiate between a dental abscess and facial cellulitis.The thermographic images obtained in this study clearly indicated a hot spot in the affected siteand it was a key indicator of the presence of an underlying medical condition, as localized heat production is a cardinal feature of infection. We found that the use of thermography increases the number of correct diagnoses compared to clinical examination alone, supporting the use of thermography as an adjunct to a clinical examination in differentiating between facial cellulitis and dental abscess.

Our data also supports the idea that thermography might be used to distinguish between various infections such as abscess and cellulitis by identifying the precise temperature distributions characteristic to each of them.[25] It was shown previously that heat emission from the surface of the body is symmetrical, with the lowest (32ºC) in the cheek area.[26-28] In this study, temperature differences between affected and contralateral unaffected sites were greater in facial cellulitis patients than in dental abscess patients. This difference could be caused by the localized nature of the abscess in comparison to the diffuse wider spread and more tissue damage associated with cellulitis, which usuallybegins with localized abscesses that progress to diffuseinflammatory cellulitis. On the other hand, when the patients in this study were divided according to gender, only females showed a significant temperature difference between facial cellulitis and dental abscess. The female sample size in this study groupwas low, resulting in alow statistical power. A larger sample is needed in order to confirm the exact association. In addition, risk factors for the gender-related temperature difference between these two conditions should be also explored in future studies.

Conclusion

Thermography is a reliable adjunctive diagnostic tool for evaluating odontogenic infections in general practice settings. Our data showed that heat emitted from a dental abscess and cellulitiswere different between genders. Further studies are recommended with a larger sample size to confirm this association.

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