



Review article

APPLICATION OF INFRARED LIGHT IN DENTAL MEDICINE. A REVIEW.

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ABSTRACT

The use of infrared (IR) light in dentistry has developed rapidly over the past few decades. Devices do not require an external energy source but can be activated by body heat. IR can be used to improve diagnosis or treatment. Currently, the use of infrared thermography (ITR) in modern medicine is experiencing continuous growth due to the technological advantages of the method in the prevention and monitoring of some diseases, the selection and evaluation of treatments, as well as its high diagnostic sensitivity and specificity reported by specialized studies.

Technological advances in the new generations of infrared detectors have led to an increase in the level of precision offered by thermal imaging as an alternative method of medical diagnosis or treatment.

The improved thermal sensitivity has contributed to the expansion of the use of IR in all medical fields, including dentistry, in specialities such as endodontics, odontology, periodontics, prosthetics, oral and maxillofacial surgery, TMJ pathology, implantology, allergology, oral pathology, photostimulation. Thermograms can be stored, processed and sent digitally, which makes them compatible with other modern technologies.

Colour coded thermograms are easier to interpret. Infrared thermography has numerous advantages, such as speed of realization, comfort for the patient, absence of contraindications and side effects, qualitative evaluation of the examined affection.

Keywords: Infrared Light, Dental Medicine, Telethermometry, Temperature, Thermography,

INTRODUCTION

Infrared radiation (IR) was first discovered in 1800 by Sir William Herschel, who found invisible emission in the spectrum inferior in power to red light by measuring its effect on a calorimeter [1]. Infrared light is electromagnetic radiation with wavelength longer than that of visible light. It is invisible to humans. IR wavelengths extend from the red edge of the visible spectrum at wavelength 700 nanometers to 1 millimeter [2-3].

IR can be used to study human or animal body temperature. This radiation was introduced first in the military field in 1830. Humans at normal body temperature emit mainly waves around 10 μm. It was first used as a medical support in 1956 to diagnose breast cancer by Lawson [4]. More often today, it's used in heat-sensitive thermal imaging, night-vision, security cameras. Most remote controls operate by infrared pulses that are recognizable by electronic devices. This includes TV remotes, DVD players and projectors. Infrared is used to send signals through fiber optic cables with silica fibers, to transmit audio to sound systems and for high-speed Internet connections. Infrared is also widely used in astronomy. Broad military and civilian applications of this radiation include target acquisition, surveillance, homing and tracking. Non-military uses are thermal analysis, environmental monitoring, industrial inspections, detection of farming operations, short range wireless communication, spectroscopy, weather forecasting, art conservation and analysis, infrared cleaning, heating, cooling, hyperspectral imaging photobiomodulation [5].

Abnormal body temperature is an indicator of inflammation. Infrared thermography (IRT) is a fast, safe, non-contact, non-invasive choice for measuring temperature. IR can map the body surface temperature remotely. It has been successfully used in the diagnosis of breast cancer, diabetes neuropathy, peripheral vascular disorders, problems associated with gynecology, kidney transplantation, dermatology, heart disease diagnosis, neonatal physiology, fever screening and brain imaging [6].

AIM

The purpose of this study is to analyze information on the scope of applications of infrared radiation in dental medicine.

MATERIALS & METHODS

Information was gathered from literature searches on the internet in databases such as PubMed and Google.

RESULTS

Infrared light is widely used in the fields of medicine. Infrared light is safe, it offers an alternative treatment for various health conditions – muscle pain, joint stiffness, arthritis, autoimmune diseases. It can play a role in an array of treatments of the human body – detoxification, reduction of muscle tension, relaxation, pain relief, improvement of circulation, weight loss, skin purification, lowering the side effects of diabetes, boosting the immune system, lowering of blood pressure. Infrared light has many benefits, including wound healing and tissue repairing, stimulating healing of ulcers and slow-healing wounds, improving hair growth, controlling psoriasis, relieving pain, improving skin appearance, reducing the side effects of cancer treatments such as oral mucositis, reducing sun damage, improving joint health, reducing scars, preventing chronic and recurring cold sores, relieving inflammation [7].

Diagnostics with IR has been used widely in dentistry. Thanks to the proven quality of IR cameras, even for smartphones, real-time temperature measurement has become an available approach to monitoring inflammation, the healing process, etc.

Medical thermography is a non-contact process that captures the surface temperature of body areas or mucosa and changes it into visible images with diagnostic value. Surface temperature is closely related to local metabolism and physiological or pathological changes in tissues and underlying systems.

BLEACHING

Infrared thermography helps identify the harmful action of the energy source, which accelerates the decomposition of bleaching agents for whitening teeth. LED lighting sources generate less heat increase on the surface of the root and pulp compared to halogen lamps, and are less harmful to dental tissues [8].

CARIOLOGY

Infrared imaging confirms the role of the transparent surface zone in dental caries or the activity assessment of root caries lesions [9, 10]

Thermography determines the pattern of heat generation, distribution and dissipation during ultra-high-speed cavity preparation. Results indicate an increase in intrapulpal temperature during cutting procedures. No significant differences in the cooling effectiveness between air-water spray and air alone were found. Thermography appears to be an effective research tool for determining thermal changes [11].

Convolutional neural networks may be useful for Near-Infrared Light Transillumination-based caries detec-

tion. This could be especially useful in non-conventional dental settings, like care homes, schools, rural outpost centers [12]. IR transillumination images showed reliability, and caries on enamel surfaces were better recognized than on radiographs [13]. Researchers at Okayama University in Japan report that optical coherence tomography, an imaging method based on infrared radiation, can be used for detecting dental caries on the surface of rear teeth [14].

ENDODONTICS

The thermomechanical filling of root canals by warm condensation with gutta-percha usually increase the root temperature. A thermographic study conducted during the sterilization of tooth roots with an 810 nm wavelength diode laser demonstrated the possibility of using this laser in compliance with certain thermal thresholds. A diode laser is safe for root canal disinfection. The temperature rise of the external root surface was below 7°C. Different output times of exposure had an effect on the temperature difference, depending on different power output levels [15]. Madura et al. used in vitro Infrared thermography (IRT) to investigate the thermal influence of Nd: YAG laser on a tooth root during the sterilization process. IRT can be successfully used for temperature monitoring of the dental tissue and for optimization of the sterilization process [16].

IR light was used to monitor the distribution of the hydraulic flow during the canals' irrigation with different irrigating endodontic needles [17].

IR was used to assess the level of periodontal harm caused by filling root canals using systems such as Thermafil Plus. No findings were discovered to indicate that this obturation system would result in damage to the periodontal ligament or the surrounding attachment apparatus as a consequence of temperature rise on the external root surface [18].

Infrared light was used to test the vitality of dental pulp. Jafarzadeh H et al. found that teeth with nonvital pulp have lower temperatures than teeth with vital pulp [19].

PERIODONTOLOGY

Warming after cooling with air for the diagnosis of inflamed gum, compared to an undamaged one, was successfully thermographically tested in 1989 by Barnett et al. [20]. Investigation from 2018 demonstrates the efficacy of IR laser treatment alone or in addition to nonsurgical/surgical periodontal therapy [21].

TMJ PATHOLOGY

Infrared thermography can be used in the diagnosis of some temporomandibular disorders, such as osteoarthritis [22]. Some investigations find correlations between TMJ arthralgia and the thermal changes of the surrounding regions. Other studies have identified a correlation between the severity of TMJ disorders and temperature [23].

Subjects with TMJ pain had increased temperature over the affected region and had asymmetrical thermal patterns [24].

ORTHODONTICS

Electro-thermal debonding, a technique for

debonding orthodontic brackets, may cause thermal damage to the dental pulpal tissue. An in vitro study found that during debonding, pulp temperature increases from 16.8 °C to 45.6 °C and may cause serious damage to dental pulp [12].

PROSTHODONTICS

Thermography has been found helpful in assessing the heat generated during the preparation of abutments for the purpose of fixed coronary restorations with whole ceramic crowns [8]. Comparisons may be made on the aggressiveness of the different grain size of grinds and cutters [25].

Thermography may be a method of polymer-oral status interrelation evaluation in denture wearers, providing information on the prevention, diagnosis or treatment of oral diseases acquired in relation to polymer dentures [26].

Thermography can be used as a diagnostic method for structural changes of the oral mucosa in candida-associated denture stomatitis, with a sensitivity and specificity similar to the culture based microbiological analysis [27].

IMPLANTOLOGY

The irrigation systems in implantology during drilling or using internal irrigation systems, the effects of the pressure, duration, drilling speed, milling design, drill sharpness, implant system, cortical thickness, depth of drilling, and bone density can also be thermographically investigated [28].

To demonstrate how the implant design influences the variation of the temperature at the marginal bone, the mean values obtained during the insertion of implants with the same dimensions (4.1 mm/10mm) and four different designs (Bone Level, Bone Level Tapered, Standard, Tapered Effect) were compared. The highest heat production was observed during the placement of bone level implants, and the lowest were assessed during the insertion of bone level tapered implants. Placement of standard implants caused the second highest temperature increase. The insertion of tapered effect implants leads to higher heat generation than the insertion of bone level tapered implants but lower than the one associated with the placement of standard ones [29].

Placing an implant with a rougher surface leads to higher heat generation than the insertion of smoother implants [29].

ORAL MEDICINE AND FOCAL INFECTION

Oral symptoms are usually not present in patients with fever of unknown origin. This allows the oral cavity to be overlooked during physical examination, and usually, fever of dental origin is neglected by doctors [30]. Krasteva A, et al. present a 50-year-old woman with chronic hepatitis B, febrile for two months (max. 38.6 °C) with characteristics of septic fever. Using thermovision diagnostics, the authors recommended extraction of diagnosed dental foci [30].

DENTAL ALLERGOLOGY

Dencheva M, et al. used thermal imaging for the examination of skin reactions in a patch test, as a non-invasive, safe, accurate method. IR light is handy in dis-

tinguishing weak, doubtful, or irritant reactions in dental allergology [31]. Another study also indicated the possible applications of thermography diagnostics in evaluating prick test results [32].

ORAL AND MAXILLO-FACIAL SURGERY

Thermographic comparative research of pathological conditions like acute inflammation, benign or malignant tumors, cystic formations, craniomandibular disorders has shown advantages and potential for further applications of thermography in diagnostics [33, 34]. Watanabe F, et al. investigated the generation and spreading of heat during the drilling of dental bone using IRT [35].

PHOTOSTIMULATION

Nerve cells respond well to IR light, and it has been proposed for photostimulation, photobiomodulation, neurostimulation, neuromodulation, regeneration, wound healing, and cancer treatment [7].

IR light makes some DNA damage in cancer cells. The mechanism is linked to oxidative stress by affecting the electron transport chain. It can also damage cellular organelles [36].

PAIN control

Gratt BM, et al. in 1996 elaborated a classification using thermograms for patients with chronic orofacial pain [36]. The thermograms were divided into normal, hot, and cold. Selected anatomic area values were 0–0.25 °C, greater than 0.35 °C and lesser than 0.35 °C, respectively. Hot thermograms indicate the clinical diagnosis of sympathetically maintained pain, peripheral nerve mediated pain, temporomandibular joint arthropathy, and maxillary sinusitis. Cold thermograms most often represent the diagnosis of peripheral nerve mediated pain, and sympathetically independent pain. Normal thermograms are found in subjects with cracked tooth syndrome, trigeminal neuralgia, and psychogenic facial pain. The methodology was found to be exact in about 92% of cases [37].

Gratt BM, et al., in 1995, concluded that IRT is effective to detect inferior alveolar nerve deficit. Patients suffering from this deficit have a mean temperature value of 0.5 °C higher in the affected area. This can be attributed to the blockage of vascular neuronal vasoconstrictive transmission [38].

DISADVANTAGES

The disadvantages of the application of Infrared Light includes thermal burns, photocarcinogenesis, and photoaging. They may be due to the thermal effects produced secondary to IR exposure rather than to the isolated effect of IR [39]. Studies have shown an increased prevalence of cataracts associated with exposure to intense infrared radiation [40]. IR raises the internal temperature of the eye. Prolonged IR exposure can lead to lens, cornea and retina damage, including cataracts, corneal ulcers and retinal burns. Skin exposed to IR provides a warning mechanism against thermal effects in the form of pain [5]. The application of the method in everyday dental practice would also be very difficult due to the need for a special apparatus.

CONCLUSION

The applications of Infrared (IR) in dental medicine have quickly advanced in recent decades. Devices do not require an external energy source, as they can be activated by the body's heat. IR can be used to improve diagnosis or treatment. Currently, the use of infrared thermography is experiencing continuous growth in modern medicine, explained by the technological advantages of the method in the prevention and monitoring of some diseases, the selection and evaluation of treatments, as well as by its high diagnostic sensitivity and specificity reported by specialized studies.

The technological progress recorded by the new generations of infrared detectors has led to an augmenta-

tion in the extent of precision offered by thermal imaging as an alternative method for medical diagnosis or treatment.

The improved thermal sensitivity contributed to the extension of IR usage in all medical fields, including dentistry, in specialties such as endodontics, odontology, periodontics, prosthetics, oral and maxillo-facial surgery, TMJ-pathology, implantology, allergology, oral pathology, and photostimulation. Thermograms can be stored, processed and shipped digitally. The interpretations are easier in color coded thermograms. Infrared thermography prevails in advantages, such as speed of realization, comfort for the patient, lack of contraindications and side effects, and qualitative evaluation of the investigated affection.

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