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THERMOGRAPHY IMAGING FOR EVALUATING THE EFFECTIVENESS AND SAFETY OF INTRACANAL CRYOTHERAPY IN PORCINE MODELS

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Abstract

The purpose of the present study is to evaluate the effectiveness and safety of intracanal cryotherapy in porcine models using thermography. Five porcine mandibles with the premolars and molars are selected. Muscles, gingiva and mucosa are retained. Endodontic preparation is done, and the jaws are annealed. Thermal imaging is conducted throughout the experiments, at a set photography interval of 15 s using ThermaCAM FLIR infrared camera. The irrigation protocol is performed with 2.5 °C 0.9% NaCl for 5 min with different volumes of irrigants – 5 mL, 10 mL, 15 mL. The irrigants are delivered using the macro cannula and the handpiece of the EndoVac system. The thermal images show the cooling of the teeth and the adjacent structures – muscles, gingiva and mucosa in the course of the experiment. The lowest temperature values reached are more than 10 °C lower than the initial values, which proves the effectiveness of the intracanal cryotherapy. The reported minimal variations (1–2 °C) in temperature values on the gingiva during intracanal cryotherapy make the method safe for use in the oral cavity. The ease of visualization makes thermal imaging a method that can be successfully applied in in vivo settings where the use of thermal sensors is impossible. Thermography is an easy, noninvasive and accurate method which can successfully be used in dental medicine.

Key words: thermography, intracanal cryotherapy, porcine jaws

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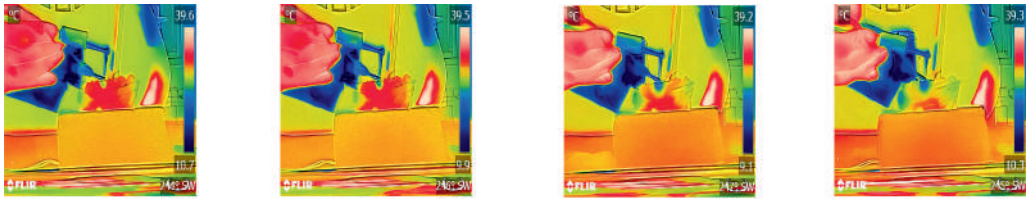
Introduction. Intracanal cryotherapy as a method of pain management after endodontic treatment has aroused interest in endodontic circles during the last decade. Borrowed from physiotherapy, in endodontics it is applied as a final irrigation of the root canal with cold solution. However, there is no uniform opinion regarding the type of irrigant-sodium hypochloride [1–3] or saline [4–6], the temperature of the irrigant [5,6], the duration of irrigation, the technique and type of irrigation system used [7], the indications and contraindications for application [8], etc. Although intracanal cryotherapy is an accessible and inexpensive method, further studies are still needed to establish specific and clearly defined parameters with precise control for safe use in clinical practice [9].

Thermography can be used to objectify the safety of the intracanal cryotherapy method in conditions similar to those of the oral cavity, namely in annealed porcine models. It is a method of measuring thermal emission and creating thermal images of the observed objects. It is a noncontact, noninvasive method that utilizes the heat from an object to detect, display, and record thermal patterns and temperature across the surface of the object and it employs images and visually evaluates the thermal changes. Various orofacial conditions in which thermography can be used are chronic orofacial pain, temporomandibular joint disorders, quantification of thermal insult to pulp, assessing inferior alveolar nerve deficit, assessing the reaction of tissue to a new dental material, for diagnosis of any kind of orofacial inflammation, etc. [10]. There is little data in the world literature on the use of thermography to evaluate the effectiveness and safety of the intracanal cryotherapy method.

Materials and methods. For the purpose of the experiment five porcine mandibles are selected. Only the segment with the premolars and molars is separated from them. Muscles, gingiva and mucosa are retained. A standard four-wall endodontic access is prepared using the Cavity Access Z Set (Dentsply Sirona, Ballaigues, Switzerland). Endodontic preparation – root canals are prepared using a rotary system (WaveOne Gold, Dentsply Sirona, Ballaigues, Switzerland) and hand endodontic files (K-files, Dentsply Sirona, Ballaigues, Switzerland). Porcine jaws are annealed in an incubator (Ivoclar, Vivadent Clinical) at a constant temperature of 37 °C for 24 h prior to the experiment. Immediately prior to the experiment, the jaw is removed from the incubator and placed in a custom-made styrofoam holder.

Thermal imaging is conducted throughout the experiments, at a set photography interval of 15 s using ThermaCAM FLIR infrared camera. The irrigation protocol is performed with 2.5 °C 0.9% NaCl for 5 min with different volumes of irrigants – 5 mL, 10 mL, 15 mL. The irrigants are delivered using the macro cannula and the handpiece of the EndoVac system.

Results. The aim of the thermal imaging study in the experiments with porcine jaws is to monitor the effect of intracanal cryotherapy in the presence of surrounding tissues – muscle, bone, gingiva, mucosa. The lowest achieved temperature values are more than 10 °C lower than the initial temperature values.



a b c d

Fig. 1. Photograph of the temperature field of the studied model obtained from the Therma CAM FLIR camera at: (a) 15 s, (b) 45 s, (c) 3.5 min, (d) 5 min

Figure 1 shows the cooling of the structures adjacent to the tooth in the course of the experiment. The ease of visualization makes thermal imaging a method that can be successfully applied in in vivo settings where the use of thermal sensors is impossible. The reported minimal variations (1–2 °C) in temperature values on the gingiva during intracanal cryotherapy make the method safe for use in the oral cavity.

Discussion. The effect of the intracanal cryotherapy is usually evaluated through Visual Analogue Scale in studies of postoperative pain in vivo [11–13]. However, this methodology is not always objective and relies on the subjective assessment of the patients. Thermography is a contemporary imaging modality based on acquiring and analyzing thermal data using non-contact devices. According to RYTIVAARA et al. [14] thermography could be a potential tool in diagnostics of temporomandibular disorders (TMD) in female patients. The results suggest that the thermal information assessed in specific facial areas could help to discriminate TMD patients from non-TMD patients and could be used to quantify the pain associated with TMD. In the present study thermography also proved to be an easy to use and accurate tool. A recent study by ABOUSHADY et al. [15] assessed the validity of thermography, compared with that of the reference-standard, for the diagnosis of periapical inflammatory lesions and evaluated the temperature ranges for acute pulpitis with apical periodontitis, acute periapical abscess and chronic periapical abscess. The authors concluded that thermography is an effective, quantitative and nonionizing approach that can be used for the diagnosis of periapical inflammatory lesions and detection of inflammatory reactions during the preclinical stage. In the present study thermography was successful in detecting the effectiveness of intracanal cryotherapy. KOMORIYAMA et al. [16] showed that there were differences in temperature within the oral cavity between teeth, free gingiva, attached gingiva, and alveolar mucosa by identification of these tissues on thermal images. The data from the present study is in agreement with the findings of Komoriyama et al. The reported minimal variations (1–2 °C) in temperature values on the gingiva during intracanal cryotherapy make the method safe for use in the oral cavity and the thermography successfully proved it.

Conclusions. In dentistry, thermography can become an important diagnostic tool, because of its accurate measurement of regional temperature and differentiation of minor temperature difference with or without any invasive procedural involvement. After treatment, thermograms can give important data about the treatment methods and their efficiency. The advantages of the method are its non-invasive technique, easy seating examination, minimal examination time, obvious difference in colour changes, easy storing of thermograms, etc.

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