In Vivo Intracanal Temperature Evolution during Endodontic Treatment after the Injection of Room Temperature or Preheated Sodium Hypochlorite

Ferdinand de Hemptinne, DDS,* Gunter Slaus, DDS, Mathieu Vandendael, DDS,* Wolfgang Jacquet, PbD,*‡ Roeland J. De Moor, DDS, MMS, PbD,‡ and Peter Bottenberg, DDS, PbD*

Abstract

Introduction: Heating a sodium hypochlorite solution improves its effectiveness. The aim of this study was to measure the in vivo temperature changes of sodium hypochlorite solutions that were initially preheated to 66°C or at room temperature inside root canals during routine irrigation. Methods: Thirty-five root canals were prepared to ISO size 40 with 4% taper. A type K (nickel-chromium-nickel) thermocouple microprobe (Testo NV, Temat, Belgium) was positioned within 3 mm of the working length to measure the temperature at 1-second intervals. In each canal, 2 test protocols were evaluated in a randomized order with 3% sodium hypochlorite solutions: (1) preheated to 66°C and (2) at room temperature. The temperature measurements began 5 seconds before the 25 seconds of irrigant injections and continued for 240 seconds. This result was in 270 data points for each protocol. Results: The temperature of the irrigant at room temperature increased from the initial intracanal temperature after injection of 20.7°C (±1.2°C) to 30.9°C (±1.3°C) in 10 seconds and to 35°C (±0.9°C) after 240 seconds. The temperature of the preheated to 66°C solution decreased from 56.4°C (±2.7°C) to 45.4°C (±3.0°C) after 5 seconds, reached 37°C (±0.9°C) after 60 seconds, and reached 35.7°C (±0.8°C) after 240 seconds. Conclusions: The original temperatures of the sodium hypochlorite solutions were buffered inside the root canal and tended to rapidly evolve to equilibrium. The findings of this study contribute to an improved understanding of the thermodynamic behaviors of irrigant solutions inside root canals in vivo. (J Endod 2015;41:1112–1115)

Key Words

In vivo, intracanal temperature, irrigation, sodium hypochlorite

The currently available evidence is strongly in favor of the use of sodium hypochlorite (NaOCl) as the preferred endodontic irrigant (1–3). NaOCl can dissolve pulp tissue (4) and is a potent antimicrobial agent (5). Additionally, NaOCl is a good lubricant for endodontic instruments and helps flush debris from the canal system (6). Different techniques have been investigated to enhance the efficacy of NaOCl (1, 3), and its efficacy would permit the use of a less concentrated NaOCl with minimal risk of toxicity or side effects (7). Heating NaOCl enhances its antimicrobial action (8, 9) as well as its tissue (9–12) and smear layer (13) dissolution capacity. The efficiency of heated NaOCl results from an acceleration of the reaction rate and an improvement in irrigant flow (14). Increases in the temperatures of irrigants are obtained via preheating the irrigant inside the syringe (9, 15); by heating the NaOCl inside the canal with a System B plugger (SybronEndo, Orange, CA) (16); or through the use of ultrasonic devices (17–19), electrosterilization (6), or lasers (20).

To our knowledge, the study by Cunningham and Balekjian (10) is the only study that has assessed temperatures in human root canals in vivo. In that study, recordings from inside different types of teeth were made with a digital microprobe thermometer. The temperatures ranged from 31°C–35.5°C. Irrigant that was injected into the canal at room temperature reached equilibrium at a temperature between the room and body temperatures after 1 to 2 minutes. The temperatures varied according to the tooth’s size, the tooth’s location, and the ambient temperature of the operating site. However, the exact methods used and details of the findings obtained by Cunningham and Balekjian were not described in their article because in vivo temperature measurement was not the primary objective of their study.

The aims of the current study were to elaborate a method for the measurement of the temperatures of intracanal irrigation solutions in opened root canals during endodontic treatments in vivo and to examine the difference in temperature changes between room temperature and preheated irrigation solutions after injection.

Materials and Methods

Patient Selection and Root Canal Preparation

The study was independently reviewed and approved by the ethics committee of the institution under B.U.N.B14320108114. The participants were selected consecutively from the set of patients who were referred to the Department of Endodontics at our dental institute from July 2012 through March 2014. The experiments were performed with the understanding and written consent of each subject and according to the World Medical Association, Declaration of Helsinki version 2008. Based on a pilot study (N = 11), a sample size of 34 teeth was calculated with G*Power 3.1 (Heinrich Heine Post Hoc University, Düsseldorf, Germany) for a power of 80% with a standardized effect size of 0.5 at an alpha error probability of 0.05. Thus, the sample size of 35 teeth (10 incisors or canines, 13 premolars, and 12 molars) was considered sufficient. The endodontic treatments were performed by a single operator (FdH) according to international guidelines (Guide to Clinical Endodontics, American Association of Endodontists, 2013). Chemomechanical preparation was performed under abundant irrigation with 3% NaOCl (Vista Dental Products, Racine, WI) at room temperature using a plastic syringe and a 30-G (0.255-mm) side-vented stainless steel needle (21) (Terumo,
Leuven, Belgium). Reciproc R25 files followed by Mtwo 40 files with 4% taper (VDW GmbH, Munchen, Germany) were used for the preparations within 0.5 mm of the apices. The positions of the files were verified electronically using a Raypex 5 apex locator (VDW GmbH).

**Measuring Device**

A Testo 21327873 flexible, mass-poor, submersion measure point type K (nickel-chromium-nickel) thermocouple microprobe (TCMP) with a diameter of 0.25 mm (Testo NV, Temat, Belgium) coupled to a Testo 735 thermocouple data recorder (Testo) was used. Temperature was recorded at 1-second intervals. The data were then transferred to a personal computer for quantitative and graphic analyses using Comfort Software X35 (Testo). An ISO 9001 Calibration Certificate was obtained (1227231_1) for the combination of the TCMP, the thermometer, and the computer. The resolution was 0.1°C, the accuracy was ±0.3°C, and the response time was 1 second. The TCMP was sterilized conventionally according to the manufacturer’s instructions.

**Measuring Procedure**

Preheated NaOCl solution (PH) was obtained by heating the filled syringe in a bottle heater (Thermobaby, Auray, France) set at position 4/5, which resulted in a mean temperature of 66°C (±1.6°C). The room temperature solution (RT) had a mean temperature of 19.4°C (±1.5°C). The TCMP and the irrigation needle were placed alongside each other in the apical third of the root canal. The insertion depths were verified using silicone stops. An apical diameter of 0.4 mm and a 4% taper allowed both the needle and the TCMP (with diameters of 0.255 mm and 0.25 mm, respectively) to be positioned within 3 mm of the apex. When this placement was not possible because of the canal’s anatomy, the measurement procedure was aborted. In teeth with multiple canals, the most accessible canal was used.

The temperature measurements were initiated 5 seconds before the injections to measure the baseline temperatures at equilibrium. Consecutively, the injection of the irrigant was initiated and continued for 25 seconds. The flow rate was 0.1 mL/s. The TCMP remained stationary in the canal during the 25 seconds of continuous injection and during the subsequent 4 minutes of rest to observe the temperature evolution. Each test protocol consisted of at least 270 data points, and both test protocols (ie, PH and RT) were conducted consecutively in each tooth. The protocol sequence was randomized (ie, PH-RT or RT-PH) for all 35 teeth although a pilot study revealed no influence of the sequence on the reproducibility of the measurements (repeated measures analysis of variance followed by a post hoc Tukey test, p = .24). Subsequently, the endodontic procedure was completed by irrigation with 17% EDTA and root canal obturation.

**Data Analyses**

Graphs of the intracanal temperatures as functions of time were drawn with Prism 5.0 (GraphPad Software Inc, San Diego, CA). The following characteristic time points were chosen to facilitate the analyses: initially at the end of the irrigant injection and 2, 5, 15, 30, 60, 120, and 240 seconds after the end of irrigant injection. The statistical calculations were performed using SPSS 22.0 (SPSS Inc, Armonk, NY).

**Results**

The temperature changes are depicted in Figure 1A and B. The temperatures at the predetermined time points are listed in Table 1. The mean intracanal temperature before injection was 35.1°C (±1.0°C), and the mean temperature inside the PH syringe before injection was 66°C (±1.6°C). Five seconds after the initiation of the PH injection, the mean intracanal temperature reached 57°C (±3.5°C) and remained constant by showing a temperature of 56.4°C (±2.7°C) at the end of the injection. After injection of the irrigant, the temperature evolved as follows: after 5 seconds, the mean intracanal temperature (PH) decreased to 45.4°C (±3.0°C), after 1 minute the temperature was 37°C (±0.9°C), and after 4 minutes it was 35.7°C (±0.8°C) in the PH protocol.

The mean temperature inside the syringe in the RT protocol before injection was 19.4°C (±1.5°C). The mean apical intracanal temperature at the end of the injection was 20.7°C (±1.2°C). Five seconds after the end of irrigant injection, the temperature (RT) was 28.9°C (±3.1°C). At 1 minute, the temperature was 34.2°C (±0.7°C), and after 4 minutes it was 35°C (±0.9°C) in the RT protocol.

**Discussion**

The influence of temperature on the efficacy of NaOCl has been reported in different studies (1, 6, 8–13, 15–17, 22). Different methods have been used to measure temperature changes of and in teeth. The use of infrared thermography (23, 24) and thermocouples (25) in in vitro studies has been described. These studies investigated temperature changes in extracted teeth (26), root canal models (27), or an experimental design that simulated the heat-dissipating role of the radicular supporting tissues (17, 28). The authors of the in vitro studies were cautious regarding the extrapolation of their results (10, 29), even when the models may have approximated clinical situations. The
in vivo temperature changes inside the root canal may evolve differently because of different factors. The water content of hard tissues varies between 10% and 20%, and the water content of soft tissue is approximately 70%. Moreover, the dentinal tubules need to be accounted for in in vitro tests. Furthermore, the periadicular vascular system has the capacity to dissipate heat and to buffer temperature changes inside the root canal (26, 30). This feature has been termed “heat sink capacity.” In contrast, dentin is considered a good insulator (31); however, differences in dentin thickness along the root canal wall can result in nonhomogeneous temperature absorption capacities depending on the location within the root canal (26). Although some experimental setups mimic clinical situations, the most reliable approach appears to be the use of in vitro measurements (32).

Despite the laborious nature of positioning the TCMP and the injection needle, the present study revealed that in vitro intracanal temperature measurements during irrigation are possible. The pilot study showed that the repeatability of the measurements was high and that the temperature differences between repeated measurements rarely exceeded the instrument’s error margin.

The bottle warmer set to the position 4/5 was suitable for obtaining temperatures of approximately 60°C inside the syringe. For reasons of safety and manipulability, temperatures above 69°C were excluded. The efficiency of NaOCl has been proven to reach a plateau at around 15°C (15); however, initial temperatures above 65°C were necessary in the preheating setup because of the heat loss of at least 5°C inside the syringe and the heat loss while the liquid passed through the needle.

The clinical measurements conducted by Cunningham and Balekjian (9) with a thermistor revealed that an irrigant placed into a canal does not immediately absorb the temperature of the root canal. Whether the preheating of irrigants is clinically relevant remains unknown.

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The authors deny any conflicts of interest related to this study.

### References