In Vitro Infrared Thermographic Assessment of Root Surface Temperatures Generated by High-Temperature Thermoplasticized Injectable Gutta-Percha Obturation Technique

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Abstract

The aim of this in vitro study was to measure the temperature rises on the outer surface of roots produced by high-temperature thermoplasticized injectable gutta-percha technique. Thirty extracted human teeth with a single canal (15 maxillary central incisors and 15 mandibular central incisors) were used in this study. After root canal cleaning and shaping, the teeth were obturated with the injected gutta-percha heated to 160°C (Obtura II). Temperature changes on the whole mesial outer surface of the roots was measured using an infrared thermal imaging camera. It showed that the use of gutta-percha heated to 160°C to fill the maxillary central incisors and mandibular central incisors resulted in the rises of the root surface temperature by 8.5°C and 22.1°C, respectively. In conclusion, the injection of the gutta-percha heated to 160°C into the root canal of maxillary central incisors produces temperature on the outer root surfaces below the theoretical critical level and, therefore, should not cause damage to supporting periradicular tissues. The injection of gutta-percha into the root canal space of the mandibular central incisors in vitro, resulted in an elevation of the root surface temperature by more than 10°C. *(J Endod 2006;32: 438–441)*

Key Words

High-temperature injection gutta-percha, root canal obturation, temperature rise on the root surface

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0099-2399/$0 - see front matter

doi:10.1016/j.joen.2005.10.047

The current consent of many clinicians is that a three-dimensional obturation of the root canal system constitutes a key factor for successful endodontic therapy (1, 2). The root canal system has many anatomical variations, such as irregularly shaped canals, multiple canals (lateral and accessory canals), isthmuses, fins, and deltas (3–5).

Many materials have been used to obturate anatomically complicated root canal spaces. Gutta-percha is the most widely used obturation material, because of its inertness, biocompatibility, plasticity when warmed, and ease of removal for post or retreatment (1, 6, 7).

Lateral compaction of gutta-percha has proven to be a very popular and clinically effective obturation technique and is taught in most dental schools (8). However, the final root canal filling lacks homogeneity. The lateral compaction of gutta-percha may also result in vertical root fractures if excessive condensation forces are used (6, 7, 9–12).

To avoid such problems, different warm gutta-percha methods have been introduced. One of these is the high-temperature thermoplasticized injectable gutta-percha system (Obtura II, Obtura Spartan, Fenton, MO). This system consists of: a control unit, a handheld gun that contains a chamber surrounded by a heating element into which a pellet of gutta-percha is loaded, and heated to a temperature of a minimum of 160°C. When plasticized, the gutta-percha is injected through the silver needles into the prepared root canal.

Even though tooth root tissues are a poor thermal conductor (13, 14), the canal filling with heated gutta-percha may be responsible for the outer root surface temperature (15–19). Eriksson and Albrektsson (20) conducted a vital-microscopic study on temperature threshold levels for heat-induced bone tissue injury on rabbit. They found that bone tissue heating to 47°C for 1 min caused bone remodeling and fat cell necrosis. Other in vivo study by Gutmann and et al. (21) in a mongrel dog showed no apparent periodontal tissues destruction after the injection of high-temperature thermoplasticized gutta-percha (Obtura, 160°C) into the root canal. In the study cited, the changes in the temperature of the external surface of the bone overlying the roots obturated with thermoplasticized gutta-percha were also recorded and the maximum temperature elevation over 60 s was found to be 1.1°C. In another in vivo study, Molywdas et al. (22) used two beagle dogs to assess periodontal reactions after root canal filling with the same system. The obturation with gutta-percha heated to 160°C caused an inflammatory reaction and destruction of collagen fibers in the area around the apical foramen. The alveolar founding bone, the roots of the teeth and the periodontal ligament at the side of the root surfaces remained normal. During the obturation procedure no temperature measurements were taken in the periodontal ligament or on the bone overlying the roots.

Several in vitro studies have examined the temperature produced on the outer root surface during the injection of high-temperature thermoplasticized gutta-percha into the root canal (23–26). Sweatman et al. (23) measured temperature changes on the outer root surface at 2, 4, and 6 mm from the root apex and found temperature rises from 5.27 to 6.23°C, and Barkhordar et al. (24) used single thermocouple to analyze the temperature in the central part of the root, and found an in vitro maximum mean

temperature rise of 4.72°C. In another in vitro study, Hardie (25) measured the outer root surface temperature rises in the apical and middle thirds with two thermocouples and found the average values to be 5.98°C and 9.57°C, respectively. Weller and Koch (26) assessed the outer root surface temperatures when gutta-percha was heated to 160, 185, and 200°C and injected into the root canal space (Obtura II). As the temperature of the injected gutta-percha was increased from 160 to 200°C, there was also a general increase in the recorded temperatures.

In all, the studies cited the temperature rises generated by high-temperature thermoplasticized injectable gutta-percha obturation technique were measured in teeth with relatively thick root walls. Up to the present, temperature rises have not been studied, however, on the outer root surfaces in teeth with relatively thin root walls.

The aim of this in vitro study was to measure with infrared thermography the temperature changes on the outer root surfaces of maxillary and mandibular central incisors (teeth with different root wall thickness) after the injection of gutta-percha heated to 160°C (Obtura II).

Materials and Methods

Thirty extracted human teeth with a single canal (15 maxillary central incisors and 15 mandibular central incisors) were used in this study. Teeth were divided into two groups of 15 teeth each. Group 1 consisted of maxillary central incisors and group 2 of mandibular central incisors. All specimens were microscopically inspected to disclose any defects or root fractures and to confirm complete formation of apices.

An access cavity to the pulp chamber was prepared and the contents of the pulp canal space were removed. The working length was established by deducting 1 mm from the actual canal length, which had been determined by inserting a size 10 K file into the canal until the tip of the file was just visible at the apical foramen. The canals were enlarged apically to size 35 (mandibular central incisors) or 45 (maxillary central incisors) using K file. The apical one-third was flared with the step-back technique, and the middle and coronal two-thirds were shaped with sizes 2 through 4 Gates Glidden drills. The canals were irrigated with 2 ml of 1% sodium hypochlorite solution after each instrument.

The Obtura II system was prepared according to the manufacturer's instructions (Obtura II Operator's Manual 1993). The working temperature was adjusted to 160°C. A 20-gauge (maxillary central incisors) or 23-gauge (mandibular central incisors) silver needle of the Obtura delivery system was placed to within 5 mm of the prepared apical stop and the gutta-percha was expressed. When back pressure was felt, the needle was withdrawn and the a finger plugger (VDW, Munich, Germany) used to apply firm apical pressure to the gutta-percha. The remaining root canal space was back filled until gutta-percha was observed in the orifice and compacted with a hand plugger (Roeko, Langenau, Germany) to finish the obturation.

In both groups AH Plus root canal sealer (DeTrey/Dentsply, Konstanz, Germany) was used.

To obtain root canal obturation and temperature measurement, the crowns of the teeth were fixed with the entire root surface exposed to the air. Temperature changes were recorded on the whole mesial root surfaces during root canal obturation using a ThermaCam SC500 thermal imaging camera (Flir, Danderyd, Sweden). The camera was mounted on a stand perpendicular to the root surface and placed 15-cm away. The thermograms were recorded at ~1 s intervals over a period of 60 s. The experiment was carried out under controlled environmental conditions (Ta ~24.0°C, RH ~50%, air flow <0.5 m/s). The camera was calibrated for distance, ambient temperature, and emissivity of the root tissue. The emissivity of the root tissues was calculated to be 0.91.

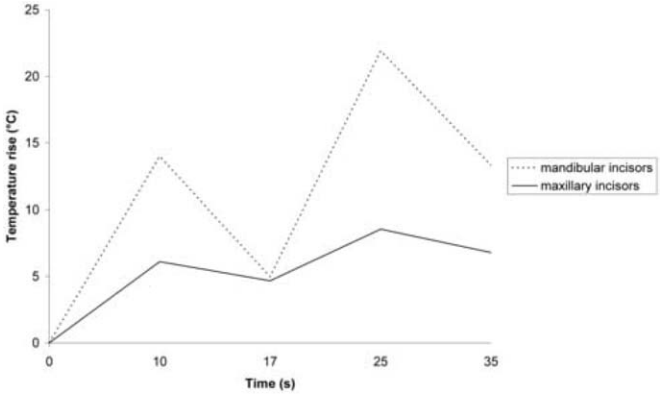

Figure 1. Mean temperature rises recorded over time.

The mean temperature rise was recorded for both groups together with the standard deviation. Analysis of the data using the Shapiro-Wilk multiverate normality test revealed a normal distribution in group I ($W = 0.922$; $p > 0.02$) and a non-normal distribution in group II ($W = 0.822$; $p < 0.007$). Therefore, the comparisons of groups were evaluated using the Mann-Whitney *U* test.

Results

The mean temperature rise recorded on the outer root surfaces of the maxillary central incisors was 8.5 ± 2.4°C (4.9-13.6), while the rise in the mandibular central incisors was 22.1 ± 7.3°C (14.9-37.2). The difference was highly significant ($p = 0.000003$).

Figure 1 shows the graphic representation of mean temperature changes. In both maxillary and mandibular incisors, the injection of heated gutta-percha into the root canal produced a two peak temperature elevations. The first showed a lower temperature of 5.9°C and 13.2°C, after introduction of the gutta-percha into the apical part of the root canal. The second showed a higher temperature of 8.5°C and 22.1°C after injection into the middle and coronal parts. After this, relatively slow decreases in temperature were recorded.

Discussion

This in vitro study investigated the outer root surface temperature increases during root canal obturation with high-temperature thermoplasticized injectable gutta-percha. The temperatures were measured using a thermal imaging infrared camera on the outer root surface of teeth with different root dentin wall thickness. It showed temperature rises of less than 10°C on the outer root surface of the maxillary central incisors and, therefore, should not have an adverse effect on the attachment apparatus of these teeth. The temperature rises below the theoretical critical level were also found in the early in vitro studies (23–28), in which gutta-percha heated to 160 to 200°C was used to fill teeth with relatively thick dentinal root walls (maxillary incisors, maxillary and mandibular canine teeth, premolars with a single canal) (Table 1).

In the present study, the temperature rises were also measured on the root surface of mandibular central incisors; teeth with relatively thin root walls (29). The mean temperature elevation was three times higher than on the root surface of the maxillary incisors. This suggests that heat transfer is dependent on the remaining radicular dentin. However, the results recorded for mandibular incisors cannot be compared to the results of other studies, because the temperature rise on the root surface in teeth with relatively thin dentinal walls as the effect of canal filling