Investigation of the Effect of Sealer Use on the Heat Generated at the External Root Surface during Root Canal Obturation Using Warm Vertical Compaction Technique with System B Heat Source

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Abstract

Introduction: During warm vertical compaction of gutta-percha, root canal sealers with different chemical compositions absorb the heat generated inside the root canal. The aim of this research was to assess physicochemical modifications of sealers subjected to the System B heat source (Analytic Technology, Redmond, WA) and to evaluate the effect that the use of different sealers has on the heat transfer to the external root surface. **Methods:** Three proprietary brand sealers (AH Plus [Dentsply International, Addlestone, UK], Pulp Canal Sealer [Kerr Corporation, Orange, CA], MTA Fillapex [Angelus Dental Solutions, Londrina, PR, Brazil]) and a prototype sealer based on Portland cement were assessed. The heat generated on the surfaces of System pluggers and the heat dissipation at different levels (apical, midroot, and cervical) over root surface while using different sealers was assessed using thermocouples. Data were collected in 3 different environmental conditions with the tooth suspended in air, immersed in Hank's balanced salt solution, or gelatinized Hank's balanced salt solution. Chemical changes in the sealers induced by the heat were monitored by Fourier transform infrared spectroscopy. The effect of heat changes on the setting time and compressive strength of the sealers was also assessed. **Results:** The continuous wave plugger sustained a rise in temperature at a maximum of 80°C at the instrument shank. The highest change in temperature on the external root surface was recorded after 1.5 minutes from the start of heating, and it was restored to body temperature by 6 minutes. Environmental conditions affected heat dissipation for all the sealers in the midroot and cervical regions and the highest increase in temperature (~60°C) recorded in air. In the midroot and cervical regions, the type of sealer used did not affect the rise in temperature. In the apical region, AH Plus obturations resulted in a greater rise in temperature, and the chemical composition of this sealer was affected by high temperature; it also induced a reduction in sealer setting time and strength. **Conclusions:** It could be concluded that surrounding conditions, such as temperature and humidity, exerted influence on heating dissipation during the continuous wave of the condensation obturation technique and that root canal sealers presented different conductive/isolating properties. Furthermore, the physical and chemical properties of AH Plus were negatively affected by the changes in temperature. *(J Endod 2014;40:555–561)*

Key Words

Characterization, endodontics, physical properties, root canal obturation, System B

Thermoplasticized gutta-percha obturation techniques not only produce a homogenous obturation adapted to root canal irregularities but also increase the density of gutta-percha inside the root canals (1, 2). System B heat source (Analytic Technology, Redmond, WA) was specifically designed to modify the vertical condensation technique and, consequently, to simplify and complete obturation faster (3). This technique was denominated "continuous wave of condensation" (4), and, although some researchers had verified lower gutta-percha density in obturations performed with System B when compared with the original technique proposed by Schilder (5) with heated spreaders and a series of specially designed pluggers (6), other studies have shown that when the System B device is used, more homogeneous (7) and coronal bacterial infiltration-resistant obturations are produced (8). Furthermore, less gutta-percha apical extrusion and leakage when compared with other thermoplasticized obturation techniques was reported (9). Obturation performed using the System B heat source usually results in better canal replication when compared with lateral compaction (10), and the main advantage of this obturation system is that the down-packing of gutta-percha can be achieved in 1 continuous motion with 1 heated plugger (11).

The use of a root canal sealer to fill voids and gaps between the main material and the root canal walls still remains indispensable because root canals filled without sealers presented greater levels of infiltration (12). However, when heat is applied to plasticize gutta-percha, the root canal sealers are subjected to heat changes inadvertently. Physical and chemical changes to sealers induced by temperature rises are still not well documented. Few studies have investigated the effects of heating on sealers' properties. It has been reported that heating did not affect the shear bond strength

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of an epoxy resin (13), but changes in viscosity were observed (14). Moreover, the effects promoted by heat on periapical tissues during warm gutta-percha obturations are still controversial. In general, it is accepted that temperature rises above 10°C of the body temperature for 1 minute can cause permanent damage to these tissues (15). Several studies have investigated the heat dissipation over human root surfaces when the System B device was used (1, 11, 16–23) but, to date, few of them have investigated the heat dissipation in relation to the oral environment (19, 20).

The purpose of this study was to assess the change in temperature at the external root surface during the heating and cooling phases of System B used to obturate root canals in different environments with different root canal sealers. Furthermore, the effect of heating on the chemical composition and physicochemical properties of the root canal sealers was also investigated.

Materials and Methods

The materials used in this study included the following conventional sealers and an experimental root canal sealer: AH Plus (Dentsply International, Addlestone, UK), MTA Fillapex (Angelus Dental Solutions, Londrina, PR, Brazil), Pulp Canal Sealer (Kerr Corporation, Orange, CA), and Prototype Sealer (Araraquara Dental School, São Paulo State University, Brazil).

AH Plus, MTA Fillapex, and Pulp Canal Sealer sealers were manipulated according to manufacturers' instructions. Prototype Sealer was composed of a mixture of white Portland cement (CPB-40; Votorantim Cimentos, Camargo Correa SA, Pedro Leopoldo, MG, Brazil), 30% replacement by weight zirconium oxide (Sigma Aldrich, St Louis, MO), and an epoxy resin composed of equal amounts of catalyst and base pastes that were mixed in a powder/liquid ratio of 5:3 (mass).

Analysis of Heat Produced by System B

The heat generated by the System B continuous-wave pluggers was recorded at 3 different levels by attaching thermocouples to the plugger surface. Type T copper-nickel thermocouples (Omega Engineering Inc, Stamford, CT) attached to a data logging device (NI 9213, 16-Channer Thermocouple Input Module; National Instruments Corp, Austin, TX) were used. The heating unit was set to 200°C and was activated for 30 seconds, and the temperature was monitored for a further 1.5 minutes with a full profile of 2 minutes.

Analysis of Heat Changes on the External Root Surface

Four human maxillary canines with complete root formation, extracted for orthodontic or periodontal reasons, were selected and cleaned of soft tissue and calculus using an ultrasonic device. The teeth were decoronated and the root length standardized at 15 mm. The working length was determined to be 1 mm shorter than the standardized root length (14 mm) using a #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland).

Biomechanical preparation was performed using the ProFile rotary system (Dentsply Maillefer, Ballaigues, Switzerland) powered by an electric motor (X-Smart, Dentsply Maillefer) at 350 rpm. The apical area was enlarged up to #40 file size and a 0.04 taper. During this process, the root canals were irrigated with 2 mL 5% sodium hypochlorite (Milton; Laboratoire Rivadis, Louzy, France) solution after each instrument, irrigation with 17% EDTA (Calasept; NordiskaDental, Angelholm, Sweden) for 5 minutes followed by 10 mL deionized water (pH = 7), and dried with absorbent paper points.

The coronal part of the roots was attached to an acrylic platform specially designed to hold the sample without the help of the operator. A central orifice was drilled through so the heat carrier could be inserted to reach the canal during obturation. The platform was fitted to a receptacle to reproduce the environmental conditions around the external surface of the root to be modified. The temperature over the surface of the teeth was evaluated in 3 different environment conditions: dry (the root was in contact with the air), immersed in Hank's balanced salt solution (HBSS, H6648; Sigma-Aldrich, St Louis, MO), and in gelatinized HBSS colloidal gel. The latter was prepared by mixing HBSS with 20% porcine gelatin (Biochemika Fluka, Sigma-Aldrich). The whole assembly was placed in an incubator, and the temperature was set at 37° ± 5°C.

The sealers were mixed and inserted into the root canals using a lentulo spiral drill. All the assembly was placed in the incubator at 37°C. The System B unit was set to 200°C in the continuous mode, and the plugger (0.06) was introduced into the root canal 4 mm shorter of the root apex. The heat source was activated for 1 minute (heating); after which, the System B device was switched off, and the temperature was monitored for a further 9 minutes (cooling). The temperature at the mesial aspect of the tooth surface was recorded every 10 seconds during both the heating and cooling phases using thermocouples attached to the coronal, midroot, and apical levels. Two extra thermocouples were placed in the incubator to monitor the temperature of the environment inside the incubator (air), and another was placed in the medium in which the specimen was immersed (HBSS or gelatinized HBSS colloidal gel) (Fig. 1). To validate the lack of variation between the heat dissipation in different roots, temperatures were monitored at different levels on the external root surface while generating heat in an empty canal.

The same sample was used for each tested sealer under the different environmental conditions investigated to avoid variations in tooth anatomy and dentine thickness and conductance that could affect results. Testing was performed in triplicate. After each test, the sealers were removed from the canals using #35 Hedströem files (Dentsply Maillefer) and irrigation with 90% ethanol.

Assessment of Changes in Chemical Composition of Sealers before and after Application of Heat

The composition of set sealers before and after simulating the application of heat by System B was investigated using Fourier transform infrared (FT-IR) spectroscopy. Sealers were manipulated and were allowed to fully set at 37°C (human body temperature) and at 100°C (simulating the temperature rise by System B) for 10 minutes in an incubator. The samples were crushed to a fine powder using a mortar and pestle, and 2–5 mg of each sealer under study was added to 100 mg

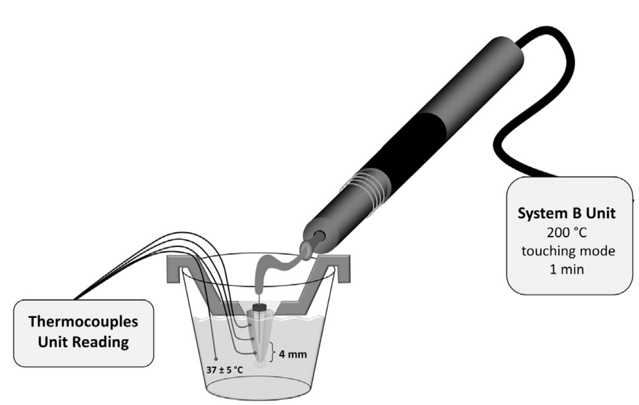

Figure 1. Experimental set-up showing tooth root with thermocouples attached at the coronal, mid-root, and apical regions with System B heat source used to generate heat within the root canal