International Endodontic Journal

doi:10.1111/j.1365-2591.2011.01889.x

Evaluation of the thermoplasticity of gutta-percha and Resilon® using the Obtura II System at different temperature settings

M. Tanomaru-Filho, R. V. S. Pinto, R. Bosso, C. A. Nascimento, F. L. C. V. Berbert & J. M. Guerreiro-Tanomaru

Department of Restorative Dentistry, Araraquara Dental School, UNESP – Univ Estadual Paulista, Araraquara, Brazil

Abstract

Tanomaru-Filho M, Pinto RVS, Bosso R, Nascimento CA, Berbert FLCV, Guerreiro-Tanomaru JM. Evaluation of the thermoplasticity of gutta-percha and Resilon® using the Obtura II System at different temperature settings. *International Endodontic Journal*, **44**, 764–768, 2011.

Aim To analyse the thermoplasticity of several endodontic filling materials using the Obtura II System at different temperature settings.

Methodology The following materials based on gutta-percha: Regular Obtura (OBT), Obtura Flow 150 (OBT F), Endo Flow (EDF), Odous (ODO) and the synthetic thermoplastic polymer material Resilon (RE) were heated using the Obtura II System at three temperature settings (140, 170 and 200 °C). Samples of the heated materials were placed on the sensor of a digital thermometer (THR-140; Instrutherm, São Paulo, Brazil) to determine their real temperature (RT) when the system was set at 140 °C (from 64.5 to 69 °C), 170 °C (from 73.8 to 77.5 °C) and 200 °C (from 83.6 °C for EDF and 100 °C for RE). Specimens (n = 30) were made by placing samples of each material in metallic ring moulds and compressing them between two glass slabs. After 24 h, specimens (n = 10) were heated at the different settings (RT) and submitted to compression under a 5-kg load. Plasticization was assessed by calculating the differences between the post-compression and initial diameters of each specimen. Data were submitted to ANOVA and Tukey's test at 5% significance.

Results At 140 °C, Obtura Flow presented the highest thermoplasticity values and Regular Obtura, the lowest. At 170 °C, Obtura Flow and Resilon demonstrated greater plasticization. Resilon had the highest mean thermoplasticity values at 200 °C.

Conclusions Thermoplasticity values were influenced both by the temperature settings on the Obtura II System and by the type of material analysed. Obtura Flow and Resilon had the highest mean thermoplasticity values.

Keywords: gutta-percha, root canal filling materials, root canal obturation.

Received 5 November 2010; accepted 3 April 2011

Introduction

Warm gutta-percha filling techniques aim to produce a homogeneous mass of filling material that fill irregularities on the root canal system (Tagger & Gold 1988, Brosco *et al.* 2003, Jarrett *et al.* 2004, Venturi *et al.* 2005, Gurgel-Filho *et al.* 2006). These techniques rely on specially designed devices or systems and have achieved excellent results in their ability to fill such canal irregularities (Wu *et al.* 2001, Jarrett *et al.* 2004, Epley *et al.* 2006, De-Deus *et al.* 2008, Anbu *et al.* 2010, Tzanetakis *et al.* 2010).

Amongst the warm thermoplasticized injection systems, the Obtura II System consists of a device in which gutta-percha pellets are heated at a preset temperature,

Correspondence: Mário Tanomaru-Filho, Rua Humaitá, 1901, apto. 182, Centro, 14801-385 Araraquara, SP, Brasil (Tel.: +55 16 3301 6390; fax: +55 16 3301 6392; e-mail: tanomaru@uol.com.br).

injected into the root canal and subjected to compaction. More recently, a thermoplastic synthetic polymer (Resilon®; Resilon Research LLC, Madison, CT, USA) has been developed as an alternative to gutta-percha. Resilon® is commercially available as cones for use in association with Epiphany sealer (Pentron Clinical Technologies, Wallingford, CT, USA) or as pellets for use with the Obtura II System.

The percentage of inorganic components in the formulation of commercially available gutta-percha may affect the thermal properties of these materials (Marciano *et al.* 1992). The thermoplasticity of endodontic filling materials is important when using thermoplastic filling systems (Tanomaru-Filho *et al.* 2007).

Several materials based on gutta-percha and Resilon may be used for the Obtura II System technique. Moreover, the temperature settings in the heating component may affect the plastic properties of the root canal filling material used. The aim of this study was to evaluate the thermoplastic property of four brands of commercially available gutta-percha and Resilon®, when subjected to different temperature settings in the Obtura II System. The null hypothesis is that different materials and temperature settings provide similar thermoplasticity for all studied materials.

Materials and methods

The thermoplasticity of the following materials was assessed: Regular Obtura gutta-percha (OBT; Obtura Spartan, Fenton, MO, USA), Obtura Flow 150 (OBT F; Obtura Spartan), EDF (EndoPoints, Amazonas, Brazil), Odous (ODO; Odous de Deus, Belo Horizonte, Brazil) and Resilon® pellets (RE; Pentron).

Assessment of the mean temperatures

Samples of each material were heated in the Obtura II System set at 140, 170 and 200 °C during 5 min. The heated materials were placed on the temperature sensor of a digital thermometer (THR-130; Instrutherm) five times for each temperature setting, to obtain the real temperature achieved by each sample. The mean temperatures of the materials heated at each setting were recorded as the real temperature for each material and setting (Table 1).

Specimens and assessment of the thermoplasticity

These procedures were carried out as previously described by Tanomaru-Filho *et al.* (2007). Specimens of each material ($n = 10$) were made by immersing the gutta-percha and Resilon® samples in a thermostat-controlled water bath (Righetto e Cia., Campinas, Brazil) set at 70 °C for 60 s. After that, the heated materials were placed in standardized metallic ring moulds measuring 10 mm in diameter by 1.5 mm in height, and the assembly was compressed between two glass slabs under a load of 0.5 N for 1 min, forming the specimens.

Table 1 Mean and standard deviation of the real temperatures found for each material after heating in the Obtura II System set at 140, 170 and 200°C

Obtura II System	Temperature 140°C	Temperature 170°C	Temperature 200°C
Obtura	64.54 (±2.3)a	77.56 (±1.3)a	89.42 (±1)b
Obtura Flow	69.06 (±2.8)a	74.88 (±2.4)a	91.9 (±1.1)b
Endo Flow	64.68 (±2.1)a	76.08 (±3.1)a	83.65 (±1.1)c
Resilon	68 (±2.2)a	73.6 (±5)a	99.95 (±0.6)a
Odous de Deus	68.74 (±2.5)a	76.02 (±2.5)a	92.6 (±2.5)b

Identical letters in the same column indicate statistically similar means.

The images of the specimens were digitized and standardized using the Adobe Photoshop software, then imported into the Image Tool software (UTHSCSA Image Tool for Windows, version 3.0; San Antonio, TX, USA). The original area of each sample was recorded.

Specimens were subsequently returned to the water bath for 2 min in the thermostat-controlled water bath (Righetto e Cia.) set at the real temperature previously determined at different settings: 140, 170 and 200°C. Each material was studied at the specific obtained real temperature (Table 1). After that, the specimens were placed between two glass slabs on a flat surface, and the assembly was subjected to a compressive load of 5 kg for 2 min. Following that, the final (post-compression) images of the specimens were digitized and the final diameters were recorded in the same manner as the initial diameters. Assessment of the thermoplasticity of each specimen was carried out by the following calculation:

$$\text{Thermoplasticity} = \text{Final (post-compression) area} - \text{original (pre-compression) area of the specimen}$$

Statistical analysis

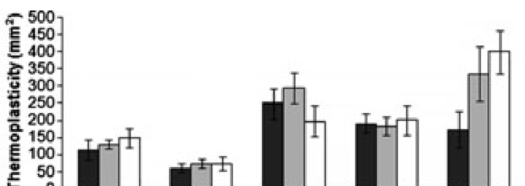
Data obtained were subjected to ANOVA at 5% significance. When statistically significant differences were found, additional comparisons were made using Tukey's test.

Results

The real temperatures recorded after the different materials were heated in the Obtura II System demonstrated that all materials achieved lower temperatures then those indicated by the equipment, as shown in Table 1. The thermoplasticity means and standard deviations for each experimental group are presented in Fig. 1. The results demonstrated that Resilon® at 200 °C setting (real temperature – 99.9 °C) had the greatest mean plasticization values ($P < 0.001$). At the 140 °C setting, the highest means were found for OBT F and the lowest values for OBT ($P < 0.001$). At the 170 °C setting, RES and OBT F had the highest means ($P < 0.05$) and OBT the lowest ($P < 0.001$). Comparison between specimens of the same material at different temperatures revealed that OBT and ODO did not differ statistically when heated at the three temperature settings. OBT F had statistically greater thermoplasticity values at the temperatures observed for the 140 and 170 °C settings, whilst Resilon® had the highest mean values at the temperatures observed at the 170 and 200 °C settings ($P < 0.05$).

Discussion

Several studies have focused on the thermoplastic properties of gutta-percha. These studies have involved the use of natural teeth with flat root canals (Wu *et al.* 2001, Jarrett *et al.* 2004, Epley *et al.* 2006, De-Deus *et al.* 2008), artificial teeth with simulated canals (Gurgel-Filho *et al.* 2006, De-Deus *et al.* 2008, Karabucak *et al.* 2008), natural teeth with artificially created irregularities (Gencoglu *et al.* 2008, Zielinski *et al.* 2008, Ordinola-Zapata *et al.* 2009), accessory canals in demineralized teeth (Venturi *et al.* 2005, Venturi 2008) and metallic blocks with simulated accessory canals (Tagger & Gold 1988). To standardize the evaluation of the thermoplasticity of the filling materials, in this study, the ANSI/ADA specification No. 57 – flow rate assessment of endodontic sealers (ISO 6876:2001, Dental Root Canal Sealing Materials) was adapted following the methodology described by Tanomaru-Filho *et al.* (2007). In this methodology, gutta-percha and Resilon® cones are subjected to compression loads of 5 kg after heating at preset temperatures. The results from the present study revealed that different materials and temperature settings resulted in a variation in the thermoplasticity of all the materials studied. Significant differences were observed in the plasticity of the materials at different temperature settings, confirming that this factor may influence the technical outcome of root filling when the Obtura II System is used. Similar results of the present study were reported by Karabucak *et al.* (2008), who evaluated the ability of the material from the Obtura II System to flow into artificially created lateral canals in plastic teeth. These authors reported that the flowability of the filling materials was a function of the properties of the materials themselves, rather than the mechanical properties of the delivery systems. Moreover, it was observed that Resilon® had higher flow rates when compared with gutta-percha, OBT and OBT F. Resilon® is generally reported to have thermoplastic properties in comparison with gutta-percha. This material has specific heat capacity (Miner *et al.* 2006, Alicia Karr *et al.* 2007). Miner *et al.* (2006) studied the thermal properties of gutta-percha and Resilon® and reported a significant difference in specific heat capacity (GP: 0.94 J (g °C)$^{-1}$, R: 1.15 J (g °C)$^{-1}$ and endothermic enthalpy change (GP: 10.88 J g^{-1}, R: 25.20 J g^{-1}) between the two materials. The heat transfer test showed a significant difference (Mann–Whitney, $P < 0.05$) in temperature increase between gutta-percha and Resilon®. These results may explain why when the device was set at 200 °C, higher temperatures were observed for Resilon®, in comparison with gutta-percha (Miner *et al.* 2006). The thermoplastic properties of Resilon® cones were previously analysed by Tanomaru-Filho *et al.* (2007) and compared with several brands of gutta-percha cones. Sant'Anna-Júnior *et al.* (2009) demonstrated that Resilon®, conventional and thermoplastic gutta-percha cones had similar temperature changes during thermomechanical compaction. Gurgel-Filho *et al.* (2003) carried out chemical and radiographic analyses on five



	EDF	OBT	OBT F	ODO	RES
■ 140°C	113,1 C.b	61,04 D.a	247,4 A.a	190,2 B.a	173 B.b
▣ 170°C	130,1 A.a	71,55 C.a	294,5 A.a	182,6 B.a	334,7 A.a
□ 200°C	147,8 B.a	73,18 C.a	196,1 B.b	200,4 B.a	399,5 A.a

Figure 1 Mean thermoplasticity values (mm^2) for the gutta-percha brands and Resilon at different temperature settings. Identical uppercase letters in the same row and identical lowercase letters in the same column indicate statistically similar mean values ($P > 0.05$).

different brands of gutta-percha and found different percentages of zinc oxide in the formulation of these materials. This variation may affect their thermoplastic properties (Karabucak *et al.* 2008). Studies have demonstrated that the flowability of gutta-percha depends on its formulation, which varies amongst different commercial brands of this material (Venturi *et al.* 2006, Karabucak *et al.* 2008). The commercial brands of gutta-percha evaluated in the present study are composed of an organic polymer (gutta-percha) and inorganic components such as zinc oxide and barium sulphate. Gurgel-Filho *et al.* (2003) suggested that lower percentages of gutta-percha in the formulation may result in diminished plasticity and flow. Flow 150 gutta-percha was specifically formulated to fill narrow root canals using small-gauge needles and have reduced density and increased flowability at lower temperatures (Karabucak *et al.* 2008). The results confirmed that differences in the formulation of different brands of gutta-percha affect the flow rate of these materials.

Conclusions

Commercial brands of gutta-percha and Resilon® pellets had different thermoplasticity values. Resilon® had more thermoplasticity when the Obtura II System was set to temperatures of 200 and 170°C and the Obtura Flow gutta-percha when the delivery system was set at 170°C.

References

Alicia Karr N, Baumgartner JC, Marshall JG (2007) A comparison of gutta-percha and Resilon in the obturation of lateral grooves and depressions. *Journal of Endodontics* **33**, 749–52.

Anbu R, Nandini S, Velmurugan N (2010) Volumetric analysis of root fillings using spiral computed tomography: an in vitro study. *International Endodontic Journal* **43**, 64–8.

Brosco HV, Bernardineli N, Moraes IG (2003) In vitro evaluation of the apical sealing of root canals obturated with different techniques. *Journal of Applied Oral Science* **11**, 181–5.

De-Deus G, Reis C, Beznos D, de Abranches AM, Coutinho-Filho T, Paciornik S (2008) Limited ability of three commonly used thermoplasticized gutta-percha techniques in filling oval-shaped canals. *Journal of Endodontics* **34**, 1401–5.

Epley SR, Fleischman J, Hartwell G, Cicalese C (2006) Completeness of root canal obturations: epiphany techniques versus gutta-percha techniques. *Journal of Endodontics* **32**, 541–4.

Gencoglu N, Yildirim T, Garip Y, Karagenc B, Yilmaz H (2008) Effectiveness of different gutta-percha techniques when filling experimental internal resorptive cavities. *International Endodontic Journal* **41**, 836–42.

Gurgel-Filho ED, Feitosa JPA, Teixeira FB, Monteiro de Paula RC, Araújo Silva JB, Souza-Filho FJ (2003) Chemical and X-ray analyses of five brands of dental gutta-percha cone. *International Endodontic Journal* **36**, 302–7.

Gurgel-Filho ED, Feitosa JPA, Gomes BPFA, Ferraz CCR, Souza-Filho FJ, Teixeira FB (2006) Assessment of different gutta-percha brands during the filling of simulated lateral canals. *International Endodontic Journal* **39**, 113–8.

Jarrett IS, Marx D, Covey D, Karmazin M, Lavin M, Gound T (2004) Percentage of canals filled in apical cross sections: an in vitro study of seven obturation techniques. *International Endodontic Journal* **37**, 392–8.

Karabucak B, Kim A, Chen V, Iqbal MK (2008) The comparison of gutta-percha and Resilon penetration into lateral canals with different thermoplastic delivery systems. *Journal of Endodontics* **34**, 847–9.

Marciano J, Michailesco P, Charpentier E, Carrera LC, Abadie MJM (1992) Thermomechanical analysis of dental gutta-percha. *Journal of Endodontics* **18**, 263–70.

Miner MR, Berzins DW, Bahcall JK (2006) A comparison of thermal properties between gutta-percha and a synthetic polymer based root canal filling material (Resilon). *Journal of Endodontics* **32**, 683–6.

Ordinola-Zapata R, Bramante CM, de Moraes IG, Bernardineli N, Garcia RB, Gutmann JL (2009) Analysis of the gutta-percha filled area in C-shaped mandibular molars obturated with a modified MicroSeal technique. *International Endodontic Journal* **42**, 186–97.

Sant'Anna-Júnior A, Tanomaru-Filho M, Hungaro Duarte MA, Santos Nunes Reis JM, Guerreiro-Tanomaru JM (2009) Temperature changes in gutta-percha and Resilon cones induced by a thermomechanical compaction technique. *Journal of Endodontics* **35**, 879–82.

Tagger M, Gold A (1988) Flow of various brands of gutta-percha cones under in vitro thermomechanical compaction. *Journal of Endodontics* **14**, 115–20.

Tanomaru-Filho M, Silveira GF, Tanomaru JM, Bier CA (2007) Evaluation of the thermoplasticity of different gutta-percha cones and Resilon. *Australian Endodontic Journal* **33**, 23–6.

Tzanetakis GN, Kakavetsos VD, Kontakiotis EG (2010) Impact of smear layer on sealing property of root canal obturation using 3 different techniques and sealers. Part I. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology* **109**, 145–53.

Venturi M (2008) An ex vivo evaluation of a gutta-percha filling technique when used with two endodontic sealers: analysis of the filling of main and lateral canals. *Journal of Endodontics* **34**, 1105–10.

Venturi M, Di Lenarda R, Prati C, Breshi L (2005) An in vitro model to investigate filling of lateral canals. *Journal of Endodontics* **31**, 877–81.

Venturi M, Di Lenarda R, Breschi L (2006) An ex vivo comparison of three different gutta-percha cones when compacted at different temperatures: rheological considerations in relation to the filling of lateral canals. *International Endodontic Journal* **39**, 648–56.

Wu MK, Kastáková A, Wesselink PR (2001) Quality of cold and warm gutta-percha fillings in mandibular premolars. *International Endodontic Journal* **34**, 485–91.

Zielinski TM, Baumgartner JC, Marshall JG (2008) An evaluation of Guttaflow and gutta-percha in the filling of lateral grooves and depressions. *Journal of Endodontics* **34**, 295–8.

