Aust Endod J 2007; 33: 23–26

ORIGINAL RESEARCH

Evaluation of the thermoplasticity of different gutta-percha cones and Resilon®

Mário Tanomaru-Filho, DDS, MSc, PhD; Geraldine Faccio Silveira, DDS; Juliane Maria Guerreiro Tanomaru, DDS, MSc, PhD; and Carlos Alexandre Souza Bier, DDS, MSc

Araraquara Dental School, São Paulo State University, UNESP, Araraquara, São Paulo, Brazil

Keywords
dental materials, gutta-percha, polymers, Resilon®, root canal filling materials.

Correspondence
Dr Mário Tanomaru Filho, Universidade Estadual Paulista Júlio Mesquita Filho, UNESP, Faculdade de Odontologia de Araraquara, Departamento de Odontologia Restauradora, Rua Humaitá, 1680, Centro, Araraquara, São Paulo, Brazil CEP:14801-903. Email: tanomaru@uol.com.br

doi: 10.1111/j.1747-4477.2007.00063.x

This article is based on a study presented at the 22nd Annual Meeting of the Brazilian Society of Dental Research (Brazilian Division of the International Association for Dental Research) in Águas de Lindóia, Brazil on 4 September 2005.

Abstract

The goal of this study was to evaluate the thermoplasticity of conventional and thermoplastic gutta-percha and Resilon®, a polyester polymer-based material. Specimens with standardised dimensions were made from the following materials: conventional and thermoplastic gutta-percha (Dentsply), conventional and thermoplastic gutta-percha (Endopoints) and Resilon®. After 24 h, the specimens were placed in water at 70°C for 60 s, and thereafter positioned between two glass slabs. Each set was compressed by a 5-kg weight. Digital images of the specimens before and after compression were obtained and analysed. The thermoplasticity of each material was confirmed by the difference between final and initial areas of each sample. The data were analysed statistically by ANOVA and Tukey's test at a 5% significance level. Resilon® had the highest thermoplasticity means ($P < 0.05$). Among the gutta-percha cones, Endopoints TP (thermoplastic) presented the highest thermoplasticity means and differed significantly from the other commercial brands ($P < 0.05$). Resilon® had good thermoplasticity, endorsing its use as a thermoplastic root canal filling material.

Introduction

One of the main objectives of endodontic treatment is the filling of the root canal to provide a good seal and to allow periapical repair (1). In this procedure, the root canal is usually filled with gutta-percha cones in association with an endodontic sealer. In some root canal obturation techniques, cold gutta-percha cones are used, while in other methods, warm gutta-percha is compacted or thermatic compaction is applied (2–4).

Considering that root canal sealers may display solubility or shrinkage during setting (5,6), it has been suggested that the ideal root canal filling should consist of a sufficient volume of gutta-percha, associated with a thin layer of sealer (2,3,6). Several obturation techniques involving the use of thermoplastic gutta-percha have been evaluated as to their effectiveness in filling irregular or lateral canals (2–4,7–11).

In thermoplastic or thermomechanical methods of root canal obturation, it is important to examine the properties of gutta-percha when the material is heated (12–14). The thermoplasticity of gutta-percha cones has been reported as being affected by their chemical composition (13,15–18), as well as by thermal alterations induced during manufacturing and use (15,17).

Resilon® (Resilon Research LLC, Madison, CT, USA) is a thermoplastic synthetic polymer-based root canal filling material recently introduced to the market. This material replaces gutta-percha cones and is available in the Resilon®/Epiphany System. According to the manufacturer, the polymers in Resilon® provide the material with thermoplastic properties (19–21) that allow its application in techniques that rely on thermoplasticity. According to Miner *et al.* (22), the melting point of Resilon® is the same as that of gutta-percha (60°C).

Several endodontic techniques have been evaluated regarding their ability to fill the root canal and its irregularities (2–4,7–11). Nevertheless, few studies have focused on the thermoplasticity of different brands of gutta-percha cones used in thermomechanical methods (18,23,24).

Some currently manufactured gutta-percha cones contain greater volumes of gutta-percha in order to improve

Table 1 Endodontic filling materials used in the experimental groups

Material	Manufacturer
Dentsply (conventional gutta-percha)	Dentsply Indústria e Comércio Ltda., Petrópolis, RJ, Brazil
Dentsply TP (thermoplastic gutta-percha)	Dentsply Indústria e Comércio Ltda., Petrópolis, RJ, Brazil
Endopoints (conventional gutta-percha)	Endopoints Indústria E Comércio Ltda., Paraiba do Sul, RJ, Brazil
Endopoints TP (thermoplastic gutta-percha)	Endopoints Indústria E Comércio Ltda., Paraiba do Sul, RJ, Brazil
Resilon®	Pentron Clinical Technologies, Wallingford, PT, USA

their thermoplastic properties (18). As these properties are essential for the success of numerous root canal filling techniques, the purpose of this study was to assess the thermoplasticity of different commercially available brands of conventional and thermoplastic gutta-percha cones compared with Resilon® synthetic polymer.

Materials and methods

For thermoplasticity analysis, five cylindrical specimens (10 mm in diameter, 1.5-mm thick) were made from each examined brand of gutta-percha or Resilon®, as described in Table 1.

The material samples were kept in water at 70°C for 60 s using a thermometer-controlled heating apparatus (Righetto e Cia., Campinas, São Paulo, Brazil).

The heated materials were then placed into standardised rings with the above-mentioned dimensions, and were pressed between two glass slabs under a controlled and constant force of 0.5 N for 1 min. Thereafter, the specimens were removed from the moulds, the excess material was trimmed and the dimensions were checked using a digital pachymeter. The specimens were kept at a temperature between 25–30°C for 24 h and then returned to the heating apparatus at 70°C for 60 s. Next, each sample was once again positioned between two glass slabs, and a 5-kg weight was placed on top of the slabs to produce a compressive force for 2 min (Fig. 1). Digital images of each specimen were obtained before and after compression, and were examined using an image analysis software (UTHSCSA Image Tool for Windows version 3.0, San Antonio, TX, USA) to determine its area. The thermoplasticity of the materials was determined by the difference between final and initial areas of each specimen.

The data were analysed statistically by ANOVA, and multiple comparisons among the experimental groups were done by Tukey's post-hoc test. The significance level was set at 5%.

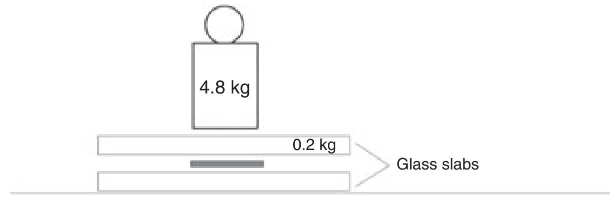

Figure 1 Apparatus used for the test.

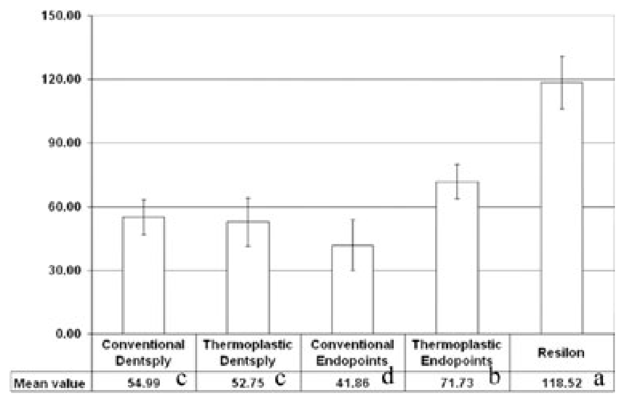

Figure 2 Means in mm^2 (±SD) of the differences between initial and final areas of each obturation material used in the experimental groups. Means followed by the same letter did not present statistically significant difference ($P > 0.05$).

Results

Means and standard deviation for the differences between initial and final areas of each material are shown in Figure 2. Statistical analysis showed that Resilon® had the highest thermoplasticity means, while Endopoints conventional gutta-percha had the lowest thermoplasticity means of all tested materials ($P < 0.05$). Among the gutta-percha cones, Endopoints TP (thermoplastic) (Endopoints Indústria E Comércio Ltda., Paraiba do Sul, RJ, Brazil) presented the highest thermoplasticity means and differed significantly from the other commercially available brands ($P < 0.05$).

Discussion

Because few studies (18,22) have focused on the differences between commercially available brands of gutta-percha, no specific methodology for testing the thermoplasticity of gutta-percha has been described. In this study, the American Dental Association specification No. 57 (for endodontic sealers) was adapted to gutta-percha testing. (ISO 6876:2002 – Dental Root Canal Sealing Materials). To evaluate the flowing ability of endodontic sealers, a 120-g weight is applied. The findings of preliminary studies showed that the force required to provide a significant increase in the diameter of heated gutta-percha specimens should be greater than 3 kg. In the present study, a 5-kg weight was used.

In search of a better root canal filling, obturation methods using heat-softened gutta-percha associated with a thin layer of endodontic sealer have been emphasised (6,25). The lateral condensation method using cold gutta-percha cones may result in voids, which are less likely in warm gutta-percha techniques (2,3,25).

Resilon®, a recently launched product, is a synthetic polymer-based root canal filling material. In the present study, Resilon® had greater thermoplasticity than the gutta-percha cones ($P < 0.05$), which supports its claimed thermoplastic properties.

According to Schilder *et al.* (13), gutta-percha has two endothermic peaks. The first peak occurs between 42 and 49°C and corresponds with the transformation from the beta phase to the alpha phase, while the other peak occurs between 53 and 59ºC when the material changes from the alpha phase to the amorphous phase. Miner *et al.* (22) observed that the melting point of Resilon® and gutta-percha is 60°C. Combe *et al.* (17) compared the endothermic peaks of non-industrialised gutta-percha to 15 commercially available brands of gutta-percha using the temperature of 70°C. For the dental gutta-percha formulations, no endothermic peak occurred at temperatures higher than 51°C. Venturi *et al.* (24) investigated three commercially available brands of gutta-percha in accessory canals at different temperatures, and found that material flow greater than 1.2 mm occurred only at temperatures higher than 60°C. Based on the findings of these studies, a temperature of 70°C was chosen for the present study.

Two gutta-percha brands were tested in this study. A conventional and a thermoplastic type of cones of each brand (as specified by their manufacturers) were used. Both brands are recommended for warm gutta-percha obturating techniques, especially when thermomechanical compactors are used. Among the gutta-percha cone, Endopoints TP showed the best thermoplasticity. Conventional and TP Dentsply (Dentsply Indústria e Comércio Ltda., Petrópolis, RJ, Brazil) cones had similar results to each other.

Gutta-percha is a natural polymer that undergoes industrial processing and addition of other substances before its application in dentistry. It has been shown that the thermoplastic properties of gutta-percha depend directly on its composition, being more pronounced in its pure form than in the manufactured version (16). Other studies have reported that the amount of inorganic fillers added, as well as thermal alterations induced during cone manufacture, may affect the material's properties (15,17,18).

The findings of a recent chemical and X-ray analysis of five commercially available brands of gutta-percha showed great variation in the amounts of zinc oxide (from 84.30 ± 0.50% to 66.50 ± 0.50%) and gutta-percha (from 14.5 ± 0.70% to 20.4 ± 0.40%). In another study involving the same brands, to evaluate their thermoplasticity and ability to fill simulated lateral canals, Gurgel-Filho *et al.* (18) verified that cones with greater percentages of gutta-percha provided the best results.

Although the materials evaluated in this study were different from those tested by Gurgel-Filho *et al.* (26), the discrepancies in the composition of gutta-percha cones may explain the observed results.

The thermoplastic properties of Resilon® are attributed to the addition of polycaprolactone, which has a melting point of 60°C (21). Our results suggest that Resilon®, presented to the market as an alternative to gutta-percha, can be used in thermoplastic techniques of root canal obturation, such as the hybrid technique proposed by Tagger *et al.* (4).

The present study may be considered as an initial model for thermoplasticity evaluation. Further research is required to increase the accuracy and standardisation of the analysis of the thermoplastic properties of gutta-percha and similar root canal filling materials.

References

1. Schilder H. Filling root canals in three dimensions. Dent Clin North Am 1967; 11: 723–44.
2. Wu M-K, Kastáková A, Wesselink PR. Quality of cold and warm gutta-percha fillings in mandibular premolars. Int Endod J 2001; 34: 485–91.
3. Jarrett IS, Marx D, Covey D, Karmazin M, Lavin M, Gound T. Percentage of canals filled in apical cross sections – an *in vitro* study of seven obturation techniques. Int Endod J 2004; 37: 392–8.
4. Tagger M, Tamse A, Katz A, Korzen BH. Evaluation of the apical seal produced by a hybrid root canal filling method, combining lateral condensation and thermatic compaction. J Endod 1984; 10: 299–303.
5. Peters DD. Two-year *in vitro* solubility evaluation of four gutta-percha sealer obturation techniques. J Endod 1986; 12: 139–45.
6. Kontakiotis EG, Wu M-K, WesselinkPR. Effect of sealer thickness on long-term sealing ability: a 2-year follow-up study. Int Endod J 1997; 30: 307–12.
7. Dulac KA, Nielsen CJ, Tomazic TJ, Ferrillo PJ Jr, HattonJF. Comparison of the obturation of lateral canals by six techniques. J Endod 1999; 25: 376–80.
8. Goldberg F, Massone EJ, Esmoris M, Alfie D. Comparison of different techniques for obturating experimental internal

resorptive cavities. Endod Dent Traumatol 2000; 16: 116–21.
9. Goldberg F, Artaza LP, De Silvio A. Effectiveness of different obturation techniques in filling of simulated lateral canals. J Endod 2001; 27: 362–4.
10. Clinton K, Himel VT. Comparison of a warm gutta-percha obturation technique and lateral condensation. J Endod 2001; 27: 692–5.
11. Bowman C, Baumgartner JC. Gutta-percha obturation of lateral grooves and depressions. J Endod 2002; 28: 220–3.
12. Goodman A, Schilder H, Aldrich W. The thermomechanical properties of gutta-percha II. The history and molecular chemistry of gutta-percha. Oral Surg 1974; 37: 954–61.
13. Schilder H, Goodman A, Aldrich W. The thermomechanical properties of gutta-percha. III. Determination of phase transition temperatures for gutta-percha. Oral Surg Oral Med Oral Pathol 1974; 38: 109–14.
14. Schilder H, Goodman A, Aldrich W. The thermomechanical properties of gutta-percha. V. Volume changes in bulk gutta-percha as a function of temperature and its relationship to molecular phase transformation. Oral Surg Oral Med Oral Pathol 1985; 59: 285–96.
15. Marciano J, Michailesco P, Charpentier E, Carrera LC, Abadie MJM. Thermomechanical analysis of dental gutta-percha. J Endod 1992; 18: 263–70.
16. Kolokuris I, Arvanitoyannis I, Blanshard JMV, Robinson C. Thermal analysis of commercial gutta-percha using differential scanning colorimeter and dynamic mechanical thermal analysis. J Endod 1992; 18: 4–9.
17. Combe EC, Cohen BD, Cummings K. Alpha and beta forms of gutta-percha in products for root canal filling. Int Endod J 2001; 34: 447–51.
18. Gurgel-Filho ED, Feitosa JPA, Gomes BPFA, Ferraz CCR, Souza Filho FJ, Teixeira FB. Assessment of different gutta-percha brands during the filling of simulated lateral canals. Int Endod J 2006; 39: 113–18.
19. Shipper G, Orstavik D, Teixeira FB, TropeM. An evaluation of microbial leakage in roots filled with a thermoplastic synthetic polymer-based root canal filling material (Resilon). J Endod 2004; 30: 341–7.
20. Shipper G, Teixeira FB, Arnold RR, Trope M. Periapical inflammation after coronal microbial inoculation of dog roots filled with gutta-percha or Resilon. J Endod 2005; 31: 91–6.
21. Tay FR, Pashley DH, Williams MC *et al*. Susceptibility of a polycaprolactone-based root canal filling material to degradation. I. Alkaline hydrolysis. J Endod 2005; 31: 593–8.
22. Miner MR, Berzins DW, Bahcall JK. A comparison of thermal properties between gutta-percha and a synthetic polymer based root canal filling material (Resilon). J Endod 2006; 32: 683–6.
23. Tagger M, Gold A. Flow of various brands of gutta-percha cones under *in vitro* thermomechanical compactation. J Endod 1988; 14: 115–20.
24. Venturi M, Di Lenarda R, Breschi L. 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. Int Endod J 2006; 39: 648–56.
25. Wu M-K, Özok AR, Wesselink PR. Sealer distribution in root canals obturated by three techniques. Int Endod J 2000; 33: 340–5.
26. Gurgel-FilhoED, Feitosa JPA, Teixeira FB, Monteiro de PaulaRC, Araújo Silva JB, Souza Filho FJ. Chemical and X-ray analyses of five brands of dental gutta-percha cone. Int Endod J 2003; 36: 302–7.