

A comparison of two gutta-percha master points consisting of different phases in filling of artificial lateral canals and depressions in the apical region of root canals when using a warm vertical compaction technique

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Abstract

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Aim Two types of gutta-percha master points consisting of different phases of the material were compared during the filling of lateral canals and depressions in the apical region of root canals when using warm vertical compaction (WVC).

Methodology Two split-tooth models were constructed one with lateral canals 1, 2 and 3 mm from the working length (WL) and another with depressions 1 and 3 mm from the WL. For each model, canal filling was performed with either alpha-phase or beta-phase gutta-percha. The gutta-percha was condensed with a System B plugger placed 7, 5 or 3 mm from the WL. The mean depth of gutta-percha penetration into the lateral canals and the percentage of depression area covered by gutta-percha were measured. A two-factor analysis of variance and a Student–Newman–Keuls test ($P < 0.05$) were used to compare the two gutta-percha and three plugger insertion depths.

Results At the 1–2 mm apical levels, alpha-phase gutta-percha and deeper plugger depth elicited better flow into canals and depressions ($P < 0.01$). At the 3 mm apical level, the alpha-phase and beta-phase gutta-percha penetrated to the same extent with 3- and 5-mm plugger insertions ($P > 0.05$); however, with the 7-mm plugger insertion, the alpha-phase gutta-percha flowed significantly more deeply than the beta-phase gutta-percha ($P < 0.01$). At the 2–3 mm apical levels, the 3 and 5 mm plugger depths elicited similar flow ($P > 0.05$); both elicited significantly better flow than the 7 mm plugger depth ($P < 0.01$).

Conclusion The alpha-phase gutta-percha with deep plugger insertion during warm vertical compaction using a System B heat source moved significantly more into lateral canals and depressions than the beta-phase gutta-percha.

Keywords: canal filling, gutta-percha master point, lateral canal, warm vertical compaction.

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Introduction

The majority of canal irregularities, including fins, deltas and lateral canals, are located in the apical third of roots (De Deus 1975, Venturi *et al.* 2005). Therefore, the apical portion of a root canal is often less well filled

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than the middle and coronal portions (Wu *et al.* 2001, Ordinola-Zapata *et al.* 2009). Canal filling by thermoplastic compaction of gutta-percha has been advocated because it seals the root canal system and reduces microbial leakage (Jacobson *et al.* 2002). The technique of warm vertical compaction (Buchanan 1996) has been shown to provide superior adaptation to canal wall irregularities, such as oval region and more complete filling of lateral canals (Clinton & Van Himel 2001, Wu *et al.* 2001). The effectiveness of gutta-percha is based on its physical properties and handling characteristics. To obtain good adaptation, gutta-percha must be sufficiently flexible to adapt to the shape of the canal walls. The flexibility of gutta-percha depends on its temperature, application time and plugger penetration (Smith *et al.* 2000, Levitan *et al.* 2003, Villegas *et al.* 2005, Venturi *et al.* 2006).

Gutta-percha exists in two distinctly crystalline phases: alpha and beta. Most commercial gutta-percha is in the beta-phase. In recent years, a number of manufacturers have marketed the alpha-phase material specifically for warm compaction techniques. The alpha-phase gutta-percha is likely to flow differently and have various other differences to beta-phase materials such as plasticity, stiffness elongation, inherent tension force and thermal behaviour (Cohen *et al.* 1992, Maniglia-Ferreira *et al.* 2007). No previous reports have compared the adaptability of alpha-phase and beta-phase gutta-percha to the canal walls.

The purpose of this study was to evaluate and compare the ability of alpha-phase and beta-phase gutta-percha to penetrate into artificial lateral canals and depressions in the apical region of root canal. Various insertion depths of the System B plugger were also compared.

Materials and methods

Tooth specimens

A split-tooth model as described previously was used. (Smith *et al.* 2000, Bowman & Baumgartner 2002, Villegas *et al.* 2005, Collins *et al.* 2006, Karr *et al.* 2007, Yelton *et al.* 2007, Zielinski *et al.* 2008). Two extracted human maxillary central incisors were used to produce two different models for canal filling; the first was the lateral canal split-tooth model; the second was the depression split-tooth model (Fig. 1). The tooth was accessed, and the working length (WL) was established 1 mm short of the anatomical foramen. The teeth were instrumented to F3 with ProTaper

rotary files (Dentsply, Tulsa, OK, USA); then, it was decoronated at the cemento-enamel junction with a 557-carbide bur (Brasseler). The root was then mounted in plastic casting resin (ETI, Fields Landing, CA, USA) and cured for 48 h at room temperature. The model was separated into labial and palatal halves through the centre of the canal with an microtome (Exakt 300, Stuttgart, Germany).

To create the split-tooth model with lateral canals, simulated lateral canals were prepared in the palatal half of the root 1, 2 and 3 mm from the WL, with a 150 µm Isomet saw blade. To create the split-tooth model with depressions, simulated depressions were prepared on the palatal wall with a silicon carbide round bur (GBC Innovations, San Diego, CA, USA); two depressions (0.5 mm deep and 0.5 mm diameter) were placed 1 mm from the WL, and one depression (0.5 mm deep and 1.5 mm diameter) was prepared 3 mm from the WL (Fig. 1). The split-tooth models were fixed in a stainless steel split model; before root canal filing, they were stored in an incubator at 37 °C with 100% humidity at all times.

Warm vertical compaction

Canal filling in the apical portion of the roots was performed according to established procedures (Buchanan 1996), except that no root canal sealer was used. A System B heat source with a fine plugger (Sybron-Endo, Orange, CA, USA). A silicone stop was placed on the plugger at the desired depth before insertion. Heat was applied while packing the material to a depth of 3 mm from the silicone stop. Apical pressure was maintained for approximately 10 s, until the stop reached the reference point. The compaction force used during filling was controlled by performing all procedures on a scale, using forces <2.0 kg (Karr *et al.* 2007). The heat button was then activated for 1 s for a separation burst of heat. After a 1-s pause, the plugger was removed with the coronal and midroot material attached to the System B plugger. A size 5 plugger (Thompson, Missoula, MT, USA) was used to compact the gutta-percha in the apical portion of the root.

The material placement and compaction forces for each filling were measured to ensure standardization among the six experimental groups of each model. Temperature and humidity were maintained at clinical conditions throughout the experiment. Root canal sealer was not used because the focus was to evaluate the ability of the different gutta-percha to flow at varying plugger insertion depths, not to evaluate the

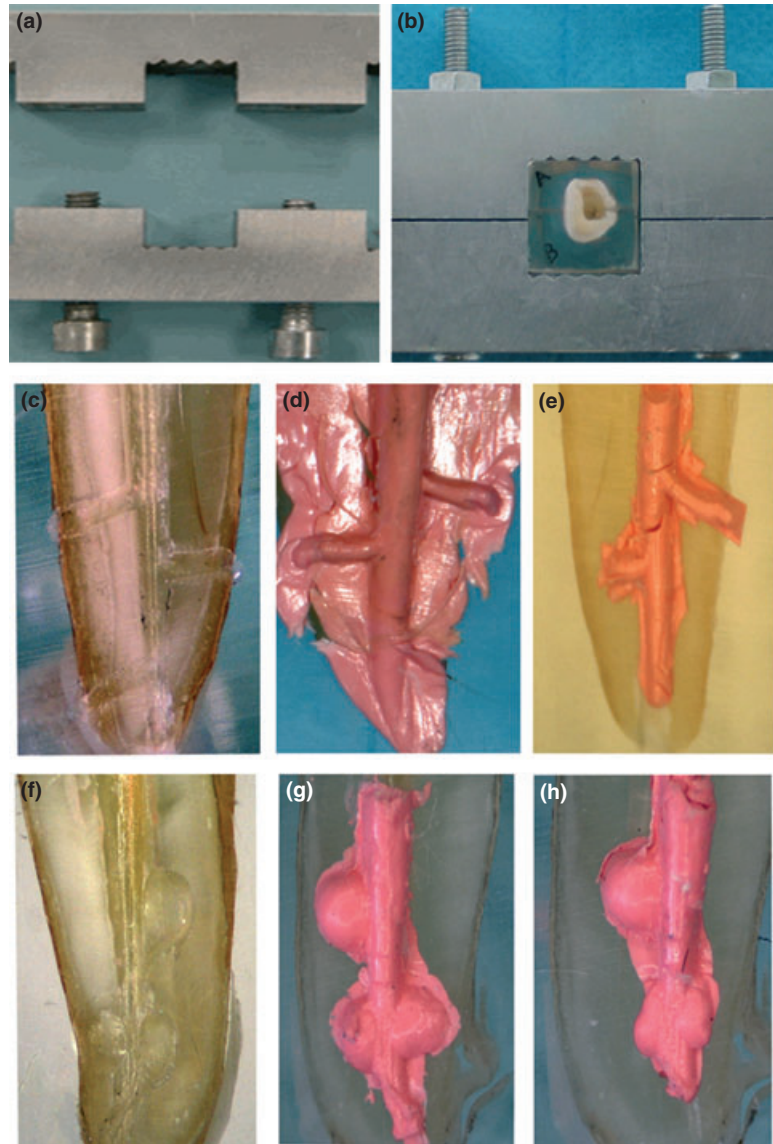


Figure 1 Representative alpha-phase and beta-phase gutta-percha filling of lateral canals and depressions at the apical level of root canals. (a) Stainless steel split mould; (b) Coronal aspect; (c) Model 1: lateral canals at the apical root canal were placed 1, 2 and 3 mm from the working length (WL); (d) Lateral groove obturation: Alpha-phase obturations with plugger insertion to 5 mm from the WL; gutta-percha extrusion between the two halves of the model was observed; (e) Lateral groove obturation: beta-phase gutta-percha with plugger insertion to 5 mm from the WL; no penetration was observed at the 1 mm level; (f) Model 2: Depressions at the apical root canal; two were placed at 1 mm and one was placed 3 mm from the WL; (g) Depression obturation: alpha-phase gutta-percha with plugger insertion to 5 mm from the WL; (h) Depression obturation: beta-phase gutta-percha with plugger insertion to 5 mm from the WL.

sealer distribution or film thickness in the split-tooth model. In addition, no backfilling was undertaken as the area of interest was the apical root canal.

Groups

For each model, root fillings were performed with either size 35, .06 taper alpha-phase gutta-percha points (Meta, Meta Biomed Co., Ltd. Cheongju City, Chungbuk, Korea), or size 35, .06 taper beta-phase gutta-percha points (Dentsply Maillefer, Ballaigues, Switzerland). In both groups, gutta-percha was condensed with a System B plugger placed 3, 5 or 7 mm from the

WL. Each experimental group comprised of 10 repeats that were completed by the same operator.

Microscopy

After each root filling, the material was allowed to cool for 5 min in the incubator; then it was separated into its buccal and palatal halves. The halves were visualized by a microscope (Olympus, Tokyo, Japan) equipped with a digital camera (Olympus, Tokyo, Japan) at 10× magnification. Samples were placed in the same position with a 0.01 mm TS-M1 microscope calibration ruler (OPLINIC, Hangzhou, China). Digital

images were evaluated with the Image-Pro plus Software. On each image, the penetration depth of gutta-percha into lateral canals (mm) and the percentage of depression area filled by gutta-percha ($= \text{gutta-percha area} / \text{depression area} \times 100\%$) were determined.

Statistical analysis

A two-factor analysis of variance (ANOVA) and Student–Newman–Keuls (SNK) tests ($P < 0.05$) were used to compare the effects of the two types of gutta-percha and three different plugger insertion depths. Differences in the mean depths of gutta-percha penetration into the lateral canals and the mean percentages of depression area covered by gutta-percha were elevated. All statistical analyses were performed with SPSS11.5 software (SPSS for Windows, version 11.5.1; SPSS Inc., Chicago, IL, USA).

Results

The mean flow depths of the alpha-phase and beta-phase gutta-percha into the lateral canals and the

mean percentages of the area of the depressions covered by gutta-percha in the apical root canal are presented in Tables 1 and 2, respectively, for the three System B plugger insertion depths.

At the 1–2 mm apical levels, the alpha-phase gutta-percha exhibited significantly better flow into lateral canals and depressions at all plugger insertion depths than the beta-phase. At the 3 mm apical level, the alpha-phase and beta-phase gutta-percha flow into lateral canals and depressions did not differ significantly at the 3 mm and 5 mm plugger insertion depths ($P > 0.05$); however, the alpha-phase gutta-percha had significantly better flow than the beta-phase gutta-percha ($P < 0.01$) at the 7 mm plugger insertion depth.

At the 1 mm apical level, it was clear that the deeper plugger depth enabled significantly better flow into lateral canals and depressions ($P < 0.01$) for both alpha-phase and beta-phase gutta-percha. At the 2–3 mm apical levels, the 3 and 5 mm plugger penetration enabled both materials to demonstrate significantly better flow when compared with the 7 mm plugger penetration ($P < 0.01$); moreover, there were

Table 1 Mean penetration depths and SDs (mm) into lateral canals with alpha-phase and beta-phase gutta-percha ($N = 10$)

Apical levels	Gutta-percha type	Plugger depths			<i>P</i>
		3 mm	5 mm	7 mm	
3 mm	Alpha-phase	1.19 ± 0.04	1.13 ± 0.04	0.85 ± 0.11^a	0.000
	Beta-phase	1.132 ± 0.06	1.07 ± 0.04	0.76 ± 0.07^b	0.000
	<i>P</i>	0.058	0.062	0.004	
2 mm	Alpha-phase	1.02 ± 0.07	0.97 ± 0.06	0.66 ± 0.07^a	0.000
	Beta-phase	0.83 ± 0.04	0.78 ± 0.05	0.34 ± 0.05^b	0.000
	<i>P</i>	0.000	0.000	0.000	
1 mm	Alpha-phase	0.45 ± 0.05^a	0.38 ± 0.04^a	0.04 ± 0.03^a	0.000
	Beta-phase	0.31 ± 0.04^b	0.17 ± 0.05^b	0.00 ± 0.00^b	0.000
	<i>P</i>	0.000	0.000	0.000	

Apical levels and plugger depths are expressed in millimetres from the apex. Significant differences ($P < 0.01$) in the depths of gutta-percha penetration into the lateral canals were observed with the System B plugger inserted to 3 mm, 5 mm or 7 mm for both alpha-phase (^a) and beta-phase (^b) gutta-percha.

Table 2 Mean percentages and SDs of the dentin depression areas filled with alpha-phase and beta-phase gutta-percha

Apical levels	Gutta-percha type	<i>N</i>	Plugger depths			<i>P</i>
			3 mm	5 mm	7 mm	
3 mm	Alpha-phase	10	0.84 ± 0.02	0.81 ± 0.02	0.74 ± 0.02^a	0.000
	Beta-phase	10	0.82 ± 0.02	0.79 ± 0.01	0.60 ± 0.06^b	0.000
	<i>P</i>		0.259	0.140	0.000	
1 mm	Alpha-phase	20	0.58 ± 0.04^a	0.55 ± 0.02^a	0.31 ± 0.04^a	0.58 ± 0.04^a
	Beta-phase	20	0.44 ± 0.03^b	0.29 ± 0.02^b	0.19 ± 0.01^b	0.44 ± 0.03^b
	<i>P</i>		0.000	0.000	0.000	0.000

Depression levels and plugger depths are expressed in millimetres from the apex. Significant differences ($P < 0.05$) in the percentages of dentin depression area filled with gutta-percha were observed with the System B plugger inserted to 3, 5 and 7 mm for both the alpha-phase (^a) and beta-phase (^b) gutta-percha.

no significant differences between the 3 and 5 mm plugger depths ($P > 0.05$).

At the 1 mm apical level, the beta-phase gutta-percha showed no flow into the lateral canals when the System B plugger was inserted to 7 mm from the WL.

Discussion

The purpose of this study was to evaluate and compare the ability of alpha-phase and beta-phase gutta-percha to flow into lateral canals and depressions in the apical root canal. The lateral canals and depressions in the models were created to simulate canal irregularities encountered clinically. Simulated lateral canals with a controlled width of 150 μm were prepared by using an Isomet saw with a 150- μm blade. Venturi *et al.* (2005) evaluated the presence of lateral canals in extracted teeth and reported that all were $<300 \mu\text{m}$ with the majority (56%) ranging from 50 to 150 μm .

The alpha-phase gutta-percha filled a higher percentage of apical canal wall depressions and penetrated more deeply into the lateral canals at the 1–2 mm apical levels at all plugger insertion depths. Moreover, the beta-phase gutta-percha did not flow into the lateral canals at the 1 mm level when the System B plugger was inserted to 7 mm from the WL. Therefore, the alpha-phase gutta-percha was superior to the beta-phase gutta-percha in fluidity and adaptability to the canal walls. Traditionally, the beta-phase gutta-percha was used to manufacture gutta-percha points to improve stability and hardness and reduce stickiness. However, more alpha-phase gutta-percha has been introduced, resulting in changes in the melting point, viscosity and tackiness of the material (Combe *et al.* 2001). The alpha-phase gutta-percha has a melting point of 64 °C. This phase is more flexible and is widely used in making gutta-percha points (Maniglia-Ferreira *et al.* 2007). Gutta-percha with greater flexibility and lower viscosity will flow with less pressure or stress, while an increase in stickiness will help create a more homogeneous filling. In the production of modern gutta-percha points, approximately 20% gutta-percha is combined with approximately 65% zinc oxide, 10% radio pacifiers and 5% plasticizers. The gutta-percha points in the present study had a similar composition of gutta-percha (about 20%) and zinc oxide (about 65%). An ideal composition of gutta-percha points can avoid the high percentage of inorganic fraction to make the points rigid, and the use of thermoplastic techniques can ease the three-dimensional root canal system filling. Gutta-

percha points contain at least 17% gutta-percha, enabling unique properties such as plasticity and good thermal behaviour during warm root canal filling (Maniglia-Ferreira *et al.* 2005).

The extrusion of gutta-percha between the two halves of the model system was observed in all filling to varying degrees, particularly with the alpha-phase gutta-percha (Fig. 1d). Such extrusion has also been reported previously (Smith *et al.* 2000, Bowman & Baumgartner 2002). During warm vertical compaction, sustained apical pressure is maintained after heat application. The compaction pressure moves the gutta-percha into the lateral canals, depressions and the interface between the two halves, demonstrating the ability of the gutta-percha to adapt to the canal configurations within the model system.

According to the previous reports (Smith *et al.* 2000, Guess *et al.* 2003, Levitan *et al.* 2003), the apical portion of the canal may be primarily occupied by sealer when the heat source insertion is not sufficiently deep. Many studies have investigated the optimal depth of heat plugger penetration to plasticize the gutta-percha at the apex. Deeper heat application is required for the plugger to penetrate to within 5 mm of the WL. This enables effective compaction of the apical gutta-percha and achieves a more effective apical seal (Yared & Bou Dagher 1995, Guess *et al.* 2003, Levitan *et al.* 2003).

Conclusion

Both the phase of gutta-percha and the depth of plugger insertion affected the quality and adaptation of warm vertical compaction canal filling in the apical root canal. It may be concluded that alpha-phase gutta-percha with deep plugger insertion flows significantly better into lateral canals and depressions in the apical root canal of a split-tooth model using the warm vertical compaction technique.

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