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The percentage of gutta-percha-filled area in simulated curved canals when filled using Endo Twinn, a new heat device source

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Abstract

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Aim To compare the percentage of gutta-percha-filled area (PGP) in simulated root canals when varying the penetration depth and function of the pluggers (heat versus heat plus vibration) using Endo Twinn.

Methodology Sixty-four resin blocks with simulated 34–35° curved canals were randomly divided into two groups in order to obtain two canal shapes: group A with 0.8 taper and group B with 0.4 taper. The apical portion of each canal was prepared to a size 20 K-file. The canals were filled with gutta-percha in combination with a root canal sealer. In each group 16 canals were filled using the Endo Twinn heat function and 16 canals by means of both the heat and the vibration function. All samples were sectioned horizontally at three levels (1.25, 2.5 and 4.0 mm from the working length) and the PGP was measured. Data were analysed using ANOVA test.

Results At the 1.25 mm level PGP was significantly greater using the vibration function ($P = 0.0329$) and in 0.8 taper canals ($P < 0.0001$). At the 2.5 mm level the PGP was greater in the canals with 0.8 taper compared with a 0.4 taper with or without vibration (vibration, $P = 0.0056$; interaction taper-vibration, $P = 0.0020$). In 0.4 taper canals the PGP was greater when the vibration function was activated. At the 4 mm level in 0.8 taper canals there was no significant difference in PGP with or without the vibration ($P = 0.6742$).

Conclusions 0.8 taper canals had significantly greater PGP than 0.4 taper canals. At the 1.25 mm level there was significantly greater PGP when the vibration function was activated.

Keywords: percentage of gutta-percha-filled area, root canal filling.

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Introduction

One of the purposes of root canal treatment is to fill the root canal system in order to prevent re-infection. Gutta-percha in conjunction with sealers is the preferred as filling material even though it is possible that sealers are soluble and not dimensionally stable over time (Kontakiotis *et al.* 1997, Wu *et al.* 1997, 2000a). A filling technique that creates a minimal amount of sealer is therefore preferred.

Warm vertical compaction of gutta-percha minimizes the amount of sealer when compared with lateral condensation (Du Lac *et al.* 1999, Smith *et al.* 2000).

The original warm vertical compaction technique (Schilder 1967) was modified by Buchanan (1996) who introduced the single continuous wave of thermoplasticized gutta-percha using a System B heat source unit. Tapered heat source pluggers with a taper similar to the canal have the potential to allow good adaptation of the root filling material to the canal wall thus reducing the amount of sealer to a thin layer between the canal wall and the gutta-percha mass.

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Several factors may affect the filling ability of the warm vertical technique. Some authors investigated the influence of heat penetration depth (Wu *et al.* 2002) and canal width (Wu *et al.* 2000b, 2002) on the adaptation of gutta-percha to the canal walls. When using different heat sources for warm vertical condensation techniques, better results were found by increasing the depth of heat application (Smith *et al.* 2000, Wu *et al.* 2002, Young Jung *et al.* 2003). Moreover, in the coronal sections, the percentage of gutta-percha-filled area (PGP) was higher than in the apical sections (Young Jung *et al.* 2003).

Another factor influencing the quality of root filling could be the use of ultrasound. Ultrasonic vibration in association with the cold lateral condensation technique produced a more complete three-dimensional filling than the cold lateral condensation technique alone (Bailey *et al.* 2004). It is possible that the vibration improved the flow of thermoplasticized gutta-percha and decreased the number and size of voids (Baumgardner & Krell 1990, Deitch *et al.* 2002). Recently, a new heat device has been introduced, Endo Twinn (Endo Twinn B.V., Amsterdam, The Netherlands), which is similar to System B with the addition of a vibration source. Endo Twinn can be used with two pluggers: Still Plugger (PC) and Ultrasoft Plugger (PF and PD). The latter is very supple and is available in several tapers and diameters that allow deep heat application even in curved canals (Wu *et al.* 2004). A preliminary report showed that vibration in combination with heat enhances the movement of gutta-percha, which results in a higher PGP value (Wu *et al.* 2004).

The purpose of this study was to investigate the influence of canal taper and depth of heat application on the PGP achieved by using Endo Twinn with and without vibration in simulated root canals.

Materials and methods

The sample size estimation was based on the following parameters: $\alpha = 0.05$; power $(1 - \beta) = 80\%$. A statistically significant difference of PGP was set at 5%.

On the basis of the results of a pilot study standard deviation of PGP in simulated root canals using Endo Twinn was 7%. Sample size calculation (Cohen 1988) was carried out by means of freeware software (Power and Sample Size Calculation Program, 1.0.17 Version).

A total of 64 standard epoxy resin blocks (Endo-training-bloc; Dentsply Maillefer, Ballaigues, Switzerland) with simulated single root canals were used. All the simulated root canals were approximately 17.5 mm in length with a curvature of 34–35°. The working length was established at 0.5 mm from the apical foramen.

The epoxy resin blocks were divided randomly into two groups, one for each preparation technique (Table 1).

Group A (0.8 taper)

The penetration depth for each file was predetermined through a preliminary study of each instrument by using the electronic motor at the speed and torque recommended by the manufacturer (ATR Tecnika, Pistoia, Italy).

A 0.12 taper sized 35 GT Rotary instrument (Dentsply Tulsa Products, Tulsa, OK, USA) was used for canal shaping followed by a 0.10 taper sized 20 GT instrument. These instruments were taken to depths of 8 and 15 mm, respectively, from the entrance of the canal. A 0.8 taper sized 20 GT Rotary instrument was used at the working length. The simulated root canals were irrigated after each instrument using 5 mL of 17% EDTA (Edta canal cleaner; Dentalica, Milan, Italy) dispensed through a 27-gauge needle; patency was confirmed by passing a size 10 K-file (Dentsply Maillefer) through the end of the canal.

Group B (0.4 taper)

The penetration depth for each file was again predetermined.

Table 1 Mean percentage (SD) of cross-sectional area filled by gutta-percha at different levels within each group

Group	1.25 mm level	2.5 mm level	4 mm level
Group A1: Endo Twinn with vibration/0.8 taper	95.86 ± 2.61	97.09 ± 1.52	93.75 ± 3.73
Group B1: Endo Twinn with vibration/0.4 taper	89.71 ± 5.57	80.93 ± 8.67	
Group A2: Endo Twinn without vibration/0.8 taper	96.76 ± 2.07	96.54 ± 1.71	94.43 ± 5.14
Group B2: Endo Twinn without vibration/0.4 taper	93.28 ± 4.99	90.44 ± 8.67	

A GT 0.12 taper sized 35 Rotary instrument (Dentsply Tulsa Products) was used for canal shaping followed by a 0.10 taper sized 20 GT, a 0.8 taper sized 20 GT Rotary instrument and a 0.6 taper sized 20 GT Rotary instrument. They were taken to a depth of, respectively, 8, 15 and 16 mm from the orifice. A 0.4 taper size 20 GT Rotary instrument was used at the working length.

The simulated root canals were irrigated as described previously.

The Endo Twinn device was used to fill the canals by randomly performing two different techniques with different pluggers.

Group A1: Endo Twinn with vibration/PD.5ML plugger (0.8 taper)

A PD.5ML ultrasoft Endo Twinn tip, with a maximum penetration depth of 5 mm from the working length, was selected and a rubber stop placed at this level; another mark was set 2 mm short of the maximum depth to indicate the binding point.

A nonstandardized medium size gutta-percha cone was trimmed 1 mm short of the working length and tugback achieved.

The root was dried with paper points, the cone coated with sealer (Pulp Canal Sealer EWT, Kerr, Romulus, MI, USA) and then placed into the canal. The Endo Twinn PD.5ML plugger tip was activated (heat and vibration) and taken to the binding point within the canal. At this depth, heat was deactivated and vibration was maintained until the Endo Twinn plugger reached the level set by the rubber stop (5 mm from the working length). Subsequently, apical pressure was maintained for 8 s. A 1 s burst of heat was applied and the plugger was removed from the canal. Backfilling of the canal was achieved by using Obtura II (Obtura Corporation, Fenton, MO, USA).

Group A2: Endo Twinn without vibration/PD.5ML plugger (0.8 taper)

Group A2 followed the same procedure as group A1, but the PD.5ML plugger was used by only activating the heat source until the binding point. Heat was then deactivated and apical pressure was maintained until the plugger reached the level set by the rubber stop.

Group B1: Endo Twinn with vibration/plugger PF.340 (0.4 taper)

The same procedure as in group A1 was carried out with the difference that plugger PF.340 was taken to a depth of 3 mm from the working length. A nonstandard medium size gutta-percha cone (Mynol; Sure Dent Corp., Seoul, Korea) was trimmed to achieve tugback at 1 mm short of the apex and then inserted into the simulated root canal.

The root was dried with paper points (Kerr) and the cone coated with sealer (Pulp Canal Sealer, EWT, Kerr, Romulus, MI, USA). The cone was then placed into the canal. The Endo Twinn PF.340 plugger tip was activated (heat and vibration) and taken to the binding point within the canal. At this depth, heat was deactivated and vibration was maintained until the Endo Twinn plugger reached the level set by the rubber stop (3 mm from the working length). Subsequently, apical pressure was maintained for 8 s. A 1 s burst of heat was applied and the plugger was removed from the canal. Backfilling of the canal was achieved by using Obtura II (Obtura Corporation).

Group B2: Endo Twinn without vibration/plugger PF.340 (0.4 taper)

Group B2 followed the same procedure as group B1, but plugger PF.340 was used by only activating the heat source until the binding point. Heat was then deactivated and apical pressure was maintained until the plugger reached the level set by the rubber stop.

All of the samples were wrapped in a gauze moistened with water and then stored at 37 °C for a week to ensure the setting of the sealer.

Calculating the PGP

Each sample was sectioned perpendicular to the axis of the main canal at 1.25 mm (level 1), 2.5 mm (level 2) and 4 mm (level 3) from the working length. Sections were obtained using a 0.4 mm thick low-speed blade (Micromet REMET, Bologna, Italy). In order to minimize the smearing of gutta-percha samples were sectioned under constant water irrigation at approximately 4 °C and minimum pressure (Wu *et al.* 2001a,b, 2002). As plugger PF.340 went deeper than 4 mm from the working length it was not necessary to section group B samples at 4 mm. As a result only the two sections at 1.25 and 2.5 mm from the working length were cut. Colour photographs of the sections were taken using a digital camera (Nikon Coolpix 4500; Nikon, Melville, NY, USA) under stereomicroscope at 40× magnification. The photographs obtained were captured as JPEG images. For each section, the root canal and the gutta-percha-filled area (excluding sealer) were measured in pixels by using ImageJ 1.33u program (ImageJ 1.33u; National Institute of Health, Bethesda, MD, USA). The measurements were performed by an operator blind to canal preparation and filling technique.

Statistics

Descriptive statistics showed mean ± standard deviation of the 1.25 mm level and 2.5 mm sections for each group. Only group A was evaluated on the 4 mm sections. For the 1.25 mm and 2.5 mm sections a full factorial design (two-way ANOVA test) was adopted where taper (0.4 vs. 0.8) was one factor and vibration (heat versus heat and vibration) the other factor. The results of the 4 mm sections were analysed by one-way ANOVA test (heat versus heat and vibration).

Results

The descriptive statistics of the percentage of gutta-percha (PGP) estimated in the 1.25 mm level, 2.5 mm level and 4 mm sections for groups A and B are showed in Table 1.

Figure 1 show the results of the 1.25 mm cross-sections; the group A1 (vibration present, 0.8 taper) had the highest PGP ($P < 0.0001$).

Figure 2 show the results of the 2.5 mm cross-sections. Two-way ANOVA test confirmed that the PGP in the 0.8 taper group was significantly greater ($P < 0.0001$) while the 0.4 taper group had significantly more PGP when the vibration function was activated (vibration, $P = 0.0056$; interaction taper-vibration, $P = 0.0020$).

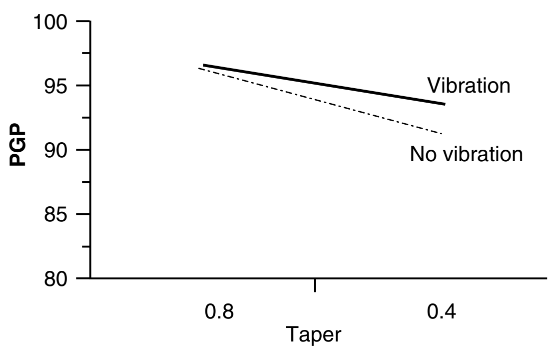

Figure 1 Graphic representation of the interaction between *taper* and *vibration* at 1.25 mm level. The continuous line represents vibration while interrupt line represents absence of vibration.

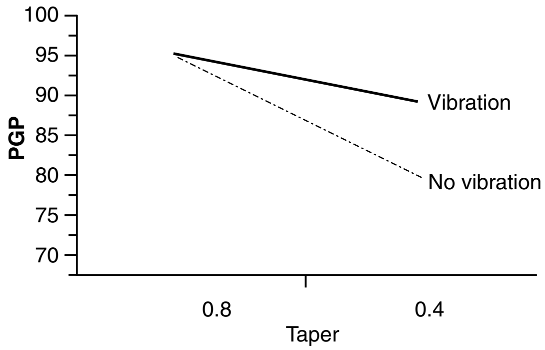

Figure 2 Graphic representation of the interaction between *taper* and *vibration* at 2.5 mm level. The continuous line represents vibration while interrupt line represents absence of vibration.

At the 4 mm level the one-way ANOVA test indicated that there was no significant difference in PGP values between group A1 and A2 ($P = 0.6742$).

Discussion

In this study a new device, the Endo Twinn, which combines heat and vibration to fill the root canal was tested. Previous studies have reported the positive effect of ultrasound on adaptation of gutta-percha when using the cold lateral condensation technique (Baumgardner & Krell 1990, Bailey *et al.* 2004). In the present study vibration associated with the continuous wave technique was used to fill 0.4 and 0.8 taper simulated root canals, using two different Endo Twinn pluggers.

The size and shape of the root canal as well as the relative choice of gutta-percha cone and pluggers are predominant variables which may influence the quality of the root filling (Cathro & Love 2003). As a result, simulated canals were used to allow the standardization of the samples.

In the present study the PGP was measured to evaluate the quality of root filling (Silver *et al.* 1999, Gencoglu *et al.* 2002, Cathro & Love 2003, Gencoglu 2003).

Although vibration increased the PGP at the 1.25 and 2.5 mm level in 0.4 taper samples and only at the 1.25 mm level in 0.8 taper samples, 0.8 taper samples always showed the best adaptation of gutta-percha to the canal walls probably as a result of a more consistent amount of filling material.

A fine nonstandardized gutta-percha cone may not fill the root canal sufficiently leaving holes or a thick layer of cement between the walls and the filling material.

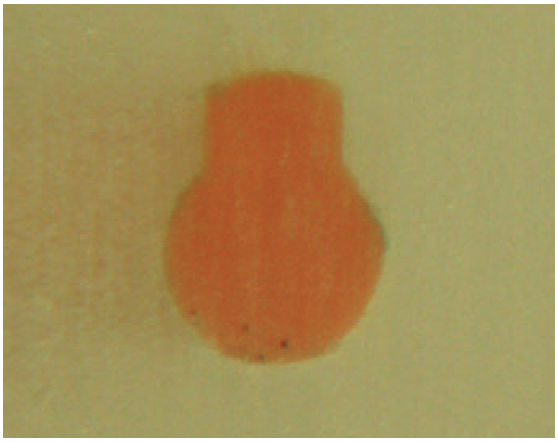

Figure 3 Cross section of simulated root canal.

Although simulated root canals were used, their cross-sections were not perfect circles following preparation (Fig. 3). Their irregular shape, which was probably due to the action of the rotary instruments on the canal walls of the resin blocks, was more evident in 0.4 taper samples. As a result there was poor adaptation of the gutta-percha to the canal walls. As well as the size and the shape of the root canal the penetration depth of the plugger also influenced PGP. Many authors suggest that in equally tapered root canals the deeper the plugger is applied the better the adaptation of gutta-percha (Smith *et al.* 2000, Wu *et al.* 2002, Young Jung *et al.* 2003). However, whenever the taper of root canal, gutta-percha cone and plugger do not correspond the continuous wave technique is not effective (Buchanan 1996). This was not the case in the present study as two different plugger penetration depths were applied to differently tapered root canals. This condition probably made PGP more sensitive to taper than to plugger penetration depth, thus resulting in a higher PGP in group A.

Conclusions

At the 1.25 mm level, cross-section of simulated root canals revealed that Endo Twinn plugger used with vibration and heat produced a higher PGP when compared with the sections obtained only using the heat function. A combination of heat and vibration produced a higher PGP at the 2.5 mm level in 0.4 taper samples. The Endo Twinn plugger PD.5ML produced a higher PGP than plugger PF.340 at all levels of the cross-section.

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