A Comparative Study of the Percentage of Gutta-percha Filled Area of Four Thermal Gutta-percha Canal Obturation Techniques

Qi Ling HUANG[1], Ying ZHANG[2], Shi Guang HUANG[1]

Objective: *To compare the percentage of gutta-percha filled area (PGFA) in the root canals filled with warm vertical condensation (WVC), Obtura II, ultrasonic lateral condensation (ULC), and cold lateral condensation (CLC).*

Methods: *Four groups (total 80) of extracted human teeth with single root were instrumented. The prepared canals were randomly divided into four groups (n = 20). Groups 1, 2, 3 and 4 were obturated with CLC, WVC, Obtura II, and ULC, respectively. Horizontal sections were cut at 3, 6 and 9 mm from the apical foramen (AF) of each tooth. The cross-sectional areas of the canal and gutta-percha were measured using an image-analysis program, and the PGFA was calculated.*

Results: *The PGFAs in both the WVC and Obtura II groups were significantly higher than those of CLC (P < 0.05). There was no difference in the PGFA between the WVC and Obtura II groups (P > 0.05). A significant difference between ULC and CLC in PGFA was only observed at 3 mm from the AF of the root.*

Conclusion: *WVC and Obtura II produced significantly higher PGFAs than those produced using ULC and CLC techniques*

Key words: *gutta-percha filled area, root canal obturation, warm gutta-percha*

Obturation plays an important role in root canal treatment. Complete obturation of the root canal system with a dimensionally stable material is the goal of conventional root canal therapy. The percentage of gutta-percha filled area (PGFA) has been used to evaluate the quality of root canal fillings[1-3]. Gutta-percha and sealer are dimensionally stable and widely used to fill root canals[4]. Some sealers shrink upon setting, and others are susceptible to decomposition[5]. It has been confirmed that leakage may occur within the sealer or by its dissolution, either in the interface between the sealer and the dentine, or between the sealer and the gutta-percha. Therefore, the areas filled by sealer are more vulnerable. This finding implies the necessity to limit its presence to a thin film and increase the amount of gutta-percha[6].

The warm vertical compaction (WVC) technique promoted by Schilder[7] provides the homogeneous and three-dimensional obturation advantages of the thermo-softened techniques. However, some disadvantages of these techniques exist, such as the need for an open flame, and that they are time-consuming and cause root fractures[8]. Electric heat, such as the Touch'n Heat (Analytic Technology, Redmond, WA, USA), has been developed to allow an easier approach to vertical condensation. The high-temperature thermoplasticised injectable obturation technique (Obtura II; Obtura, Fenton, MO, USA) demonstrates the best adaptation to the three-dimensional root canal system[9]. However, a drawback with this technique is the inability to control apical

1 Department of Dentistry, Jinan University School of Medicine, Guangzhou, P.R. China.
2 Department of Dentistry, Hunan Wantwant Hospital, Changsha, Hunan, P.R. China.
Corresponding author: Dr Shi Guang HUANG, Department of Dentistry, Jinan University School of Medicine, Guangzhou 510632, P.R. China. Tel: 020-85221165. E-mail: thshg@126.com.

extrusion of the softened gutta-percha[10]. WVC retains the length control of cold lateral condensation (CLC), and also has the superior ability of a thermoplasticised technique to replicate the three-dimensional form of the root canal. Although the ultrasonic lateral condensation (ULC) technique has been shown to be successful[11,12], there is no data comparing obturation using Touch'n Heat, Obtura II, and ULC. The present study was designed to evaluate the percentage of PGFA in root canals filled with WVC, Obtura II, ULC or CLC.

Materials and Methods

Instrumentation

A total of 80 single-root teeth without resorptive defects, caries, cracks or open apices were used. The selected teeth were carefully cleaned with curettes to remove any calculus or soft tissue debris, soaked in 5% NaOCl for 30 min, and then cleaned using 0.9% NaCl and stored in 5% neutral formalin until use.

The crowns were removed at the cemento-enamel junction (CEJ) using a carborundum disc. A size 10 file was inserted into the canal until the tip of the file was just visible at the apical foramen (AF). The working length (WL) was established 1 mm short of the apex. All the canals were prepared by one operator. The coronal and middle third of each canal was prepared using Gates Glidden drills (Dentsply Maillefer, Ballaigues, Switzerland), sizes 1 to 3. The apical portion of all the roots was enlarged to a size 25 K-type file at the working length, and the rest of the canals were flared to a size 30, 35, and 40 K-type file, using the step-back technique. The canal was then smoothed by applying the size 25 master file to the WL. Each canal was irrigated after each instrument with 2 ml of a freshly-prepared 2% solution of NaOCl and 0.9% NaCl. After completion of the preparation, the canal was irrigated with 6 ml of 17% ethylenediaminetetraacetic acid (EDTA) and 10 ml of 5.25% NaOCl. Finally, all the canals were irrigated with 0.9% NaCl and dried with paper points.

Obturation

The prepared canals were randomly divided into four equal groups (n = 20). Group 1 was obturated with CLC; Group 2 was obturated with WVC; Group 3 was obturated with Obtura II and Group 4 was obturated with ULC.

Root canal sealer (0.25 ml for each canal) was mixed manually according to the recommendations of the manufacturer and introduced into the root canal with a size 20 file.

Group 1 obturation

A size 25 master gutta-percha cone was placed in the canal to the full WL. CLC was achieved in each canal using accessory gutta-percha cones and an endodontic finger spreader size B (Dentsply Maillefer) that initially reached to within 3 mm of the full WL. A heated instrument was used to remove the excess coronal gutta-percha.

Group 2 obturation

The heat source for this group was Touch'n Heat (Sybron Endo, CA, USA). The tip of a medium-sized non-standardised gutta-percha cone was trimmed back until tug-back was achieved at WL. Three pluggers (1.1, 0.7 and 0.5 mm) were selected to fit the coronal, middle and apical third of each canal. The heat carrier was inserted into each canal to heat the gutta-percha before vertical condensation, using prefitted pluggers. Vertical condensation of the gutta-percha was completed when a vertical plugger was 4 mm from the WL. The remainder of the canal was then obturated with warmed segments of gutta-percha.

Group 3 obturation

Canals were obturated using the Obtura II unit (Obtura) according to the manufacturer's instructions. Briefly, the Obtura II unit was set to 180ºC, using a 3# gauge needle; gutta-percha was injected into the apical third of the canal 2 mm from the WL and condensed with a plugger. The remainder of the canal was back-filled using the above-mentioned technique.

Group 4 obturation

A condenser that could freely enter the canal up to the WL was selected. The power of P5 was set to 10. The master cone was placed inside the canal and the condenser was inserted and activated for 10 seconds by applying slight pressure to the dentine wall. The ultrasonic power was switched off and the condenser was removed. An accessory gutta-percha cone was inserted into the space, then released and condensed as above. This step was repeated until the canal was filled. The filled teeth were stored in 100% humidity at 37ºC for 48 hours.

Sectioning and image analysis

Each sample was horizontally sectioned 3, 6 and 9 mm from the AF, using a low-speed saw with a diamond disc

and constant cooling water, which prevented smearing the gutta-percha. The surfaces were polished using a piece of silk to remove scratches and smearing.

Photographs of the sections were taken using a Nikon ME600 microscope. Image analysis and processing were performed using Image-Pro Plus 4.0 (Media Cybernetics, Bethesda, MD, USA). The image analysis was performed by two blinded investigators. The cross-sectional area of the canal and the gutta-percha were recorded and the PGFA was calculated using the above software.

Statistical analysis

The PGFAs were analysed statistically using analysis of variance (ANOVA). The level of significance was set at $P < 0.05$.

Results

The results for the mean of PGFAs measured at 3, 6 and 9 mm from the AF are shown in Table 1.

The WVC group and Obtura II group showed significantly higher PGFAs than the CLC group ($P < 0.05$) at all three levels. No statistically-significant difference was found between the WVC and Obtura II groups at the three sections. At 9 mm from the AF, the PGFA in the ULC group was higher than that of the CLC group ($P < 0.05$) (Figs 1 to 4). PGFA in the root canal at 3 and 6 mm from the AF in the CLC and the ULC group was significantly higher than that at 9 mm from the AF ($P < 0.05$).

Discussion

The present study was designed to compare the percentage of PGFA in the root canal at 3, 6 and 9 mm from the AF when filled using WVC, Obtura II, ULC or CLC. In this experiment, samples were examined under a microscope, and measurements were made through digital image analysis and processing. In this methodology, the quality of the images is important, and the sample preparation for observation is essential. In order to provide an even plane for observation, materials with different consistencies (gutta-percha and dentine) are polished.

Gutta-percha in combination with a root canal sealer is the most commonly-used filling material. It has been reported that root canal sealer facilitates gutta-percha movement and is necessary for the best apical seal when filling with thermoplasticised gutta-percha[13]. The sealer fills the minor irregularities and acts as a luting agent between the gutta-percha and the canal wall[14,15]. The sealer is generally recommended in root canal obturation. Some investigators have not used sealer in their studies, as they thought that it would be difficult to standardise the amount of sealer in the apical canal[16]. In

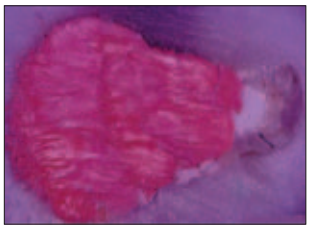

Fig 1 Cross-section of root canal filled using cold lateral condensation. The recess was unfilled (original magnification ×5).

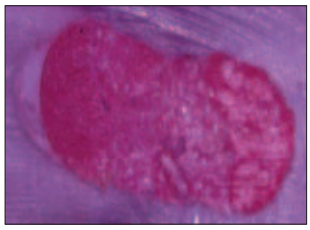

Fig 2 Cross-section of root canal filled using ultrasonic lateral condensation. Gutta-percha shows good adaptation to the canal wall (original magnification ×5).

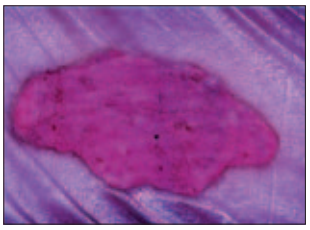

Fig 3 Cross-section of root canal filled using warm vertical condensation. Gutta-percha extends into irregular area (original magnification ×5).

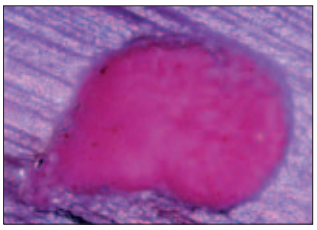

Fig 4 Cross-section of root canal filled using Obtura II. Gutta-percha becomes a homogeneous mass (original magnification ×5).

Table 1 PGFA (%) at 3, 6 and 9 mm from the AF obturated with different techniques

	PGFA (mean ± SD)		
	9 mm from the AF	6 mm from the AF	3 mm from the AF
CLC	86.52 ± 1.76	89.40 ± 2.62§	91.04 ± 1.67§
WVC	96.36 ± 2.10*	97.05 ± 2.05*	97.35 ± 1.16*
Obtura II	99.25 ± 0.81*	96.07 ± 1.30*	96.11 ± 1.38*
ULC	90.45 ± 1.53*†‡	94.13 ± 3.84§	92.84 ± 1.46†‡§

*$P < 0.05$ vs CLC; †$P < 0.05$ vs WVC; ‡$P < 0.05$ vs Obtura II; §$P < 0.05$ vs 9 mm from the AF.

the present study, we standardised the amount of sealer (0.25 ml for each canal) to minimise the amount of sealer in the canal, which reflects the clinical situation.

The action of endodontic instruments on dentine walls causes the formation of a smear layer comprising inorganic and organic matter. McComb and Smith[17] were the initial investigators to show the presence of a smear layer in instrumented root canals. Elimination of the smear layer results in smoother walls and in dentinal tubules of circular shape and slightly amplified diameter. As a consequence, the root canal wall comes into closer contact with the filling material, which penetrates the dentinal tubules, increasing adhesion and sealing capacity[18]. Several different irrigant solutions have been used to remove the smear layer. According to Braguetto et al[19], the cleaning action of EDTA in association with NaOCl solution results in cleaner canals, with a lower percentage of debris than was obtained using other solutions[19]. In the present study, the canals were irrigated with 17% EDTA and 5.25% NaOCl to remove the smear layer.

Within the experimental design of this study, the CLC group had the lowest PGFA at all sections. This finding was similar to that noted by Eguchi et al[20], where lateral condensation in the apical third was the technique with the lowest percentage of gutta-percha. Lateral condensation is thought to be unable to replicate the inner surface of the root canal.

The ULC group produced a higher PGFA than the CLC group at 9 mm from the AF. Nevertheless, no significant statistical difference was found between these two groups at 3 and 6 mm from the AF. These findings contradicted those reported by Bailey et al[21], which showed that ULC produced less unfilled space at the coronal, middle, and apical third compared with CLC. The possible reason for this difference may be the power and the activating time. The parameters used by Bailey et al[21] were that the power of P5 is set to 5 and the activating time is 10 or 15 minutes. Further research on the power and activating time setting of ULC technique needs to be performed.

In the current study, no statistically significant difference was found between the WVC group and Obtura II group at all three sections, although Obtura II produced the highest PGFA at 9 mm from the AF (PGFA = 99.25%), and WVC produced the highest PGFA at 3 and 6 mm from the AF (PGFA = 97.05% and 97.35%). There were also no significant differences among the three sections between the WVC and Obtura II groups. These results indicate that WVC and Obtura II techniques produce excellent homogeneity along the canal.

The CLC group and ULC group produced higher PGFA at 6 and 3 mm than at 9 mm from the AF. These differences indicate that the CLC and ULC techniques have better performance in round canals than in oval canals, as the long diameter of oval canals has been found to decrease apically[5]. It also showed that the homogeneity that the CLC and ULC techniques produce is not as good as WVC and Obtura II techniques.

In the present study, the PGFA that the WVC produced at 3, 6, and 9 mm from the AF were 97.35%, 97.05%, and 96.36%, respectively. Silver et al[22] reported that the PGFA at 6 mm from the AF is 97 to 98% and at 2 mm is 94.5%. Wu et al[23] reported that the PGFA reaches 94.1% at 2 mm and 99.1% at 4 mm. There are many influencing factors during canal filling with WVC, such as the temperature of the heat source, the activating time of the heater, the size of the plugger, the gutta-percha cone, the depth of heat application, and the width and shape of the apical root canal. The depth of heat application and the width of the apical root canal influence the PGFA[23].

References

1. Wu MK, Wesselink PR. A primary observation on the preparation and obturation of oval canals. Int Endod J 2001;34:137-141.
2. Wu MK, van der Sluis LW, Wesselink PR. A preliminary study of the percentage of gutta-percha-filled area in the apical canal filled with vertically-compacted warm gutta-percha. Int Endod J 2002;35:527-535.
3. De-Deus G, Gurgel-Filho ED, Magalhães KM, Coutinho-Filho T. A laboratory analysis of gutta-percha-filled area obtained using Thermafil, System B and lateral condensation. Int Endod J 2006;39:378-383.
4. Wu MK, Fan B, Wesselink PR. Diminished leakage along root canals filled with gutta-percha without sealer over time: a laboratory study. Int Endod J 2000;33:121-125.
5. Kontakiotis EG, Wu MK, Wessilink PR. Effect of sealer thickness on long-term sealing ability: a two year follow-up study. Int Endod J 1997;30:307-312.
6. De Deus GA, Martins F, Lima AC, Gurgel-Filho ED, Maniglia CF, Coutinho-Filho T. Analysis of the film thickness of a root canal sealer flowing three obturation techniques. Pesqui Odontol Bras 2003;17:119-125.
7. Schilder H. Filling root canals in three dimensions. Dent Clin North Am 1967;11:723-744.
8. Lugassy AA, Yee F. Root canal obturation with gutta-percha: a scanning electron microscope comparison of vertical compaction and automated thermatic condensation, J Endod 1982;8:120-125.
9. Budd CS, Weller RN, Kulild JC. A comparison of thermoplasticized injectable gutta-percha obturation techniques. J Endod 1991;17:260-264.
10. El Deeb ME. The sealing ability of injection-molded thermoplasticized gutta-percha. J Endod 1985;11:84-86.
11. Baumgardner KR, Krell KV. Ultrasonic condensation of gutta-percha: an in vitro dye penetration scanning electron microscopic study. J Endod 1990;16:253-259.
12. Zmener O, Banegas G. Clinical experience of root canal filling by ultrasonic condensation of gutta-percha. Endod Dent Traumatol 1999;15:57-59.
13. Evans JT, Simon JH. Evaluation of the apical seal produced by injected thermoplasticized gutta-percha in the absence of smear layer and root canal sealer. J Endod 1986;12:100-107.

14. Hata G, Kawazoe S, Toda T, Weine FS. Sealing ability of Thermafil with and without sealer. J Endod 1992;18:322-326.
15. Najar AL, Saquy PC, Vansan LP, Sousa-Neto MD. Adhesion of a glass–ionomer root canal sealer to human dentine. Aust Endod J 2003;29:20-22.
16. Smith RS, Weller RN, Loushine RJ, Kimbrough WF. Effect of varying the depth of heat application on the adaptability of gutta-percha during warm vertical compaction. J Endod 2000;26:668-672.
17. McComb, Smith DC. A preliminary scanning electron microscopic study of root canals after endodontic procedures. J Endod 1975;1:238-242.
18. Gettleman BH, Messer HH, El Deeb ME. Adhesion of sealer cements to dentin with and without the smear layer. J Endod 1991;17:15-20.
19. Braguetto CA, Souza Neto MD, Cruz Filho AM, Silva RG, Saquy PC, Pécora JD. Effect of EDTA and Dakin's solutions used alone, in association or alternatively in root canal cleaning. Rev Odontol Univ Sao Paulo 1997;11:67-70 (in Portuguese).
20. Eguchi DS, Peters DD, Hollinger JO, Lorton L. A comparison of the area of the canal space occupied by gutta-percha following four gutta-percha obturation techniques using Procosol sealer. J Endod 1985;11:166-175.
21. Bailey GC, Cunnington SA, Ng YL, Gulabivala K, Setchell DJ. Ultrasonic condensation of gutta-percha: the effect of power setting and activation time on temperature rise at the root surface – an *in vitro* study. Int Endod J 2004;37:447-454.
22. Silver GK, Love RM, Purton DG. Comparison of two vertical condensation obturation techniques: Touch 'n Heat modified and System B. Int Endod J 1999;32:287-295.
23. Wu MK, Kast'áková A, Wesselink PR. Quality of cold and warm gutta-percha fillings in oval canals in mandibular premolars. Int Endod J 2001;34:485-491.