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Evaluation of Gutta-Percha-Filled Areas in Root Canals after Filling by Two Different Obturation Techniques

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Abstract: The aim of this study was to determine the percentage of gutta-percha-filled area (PGFA) in the apical third of root canals after filling with either System B or cold lateral lateral condensation techniques. Sixty-six recently extracted human maxillary central incisors were prepared with ProTaper NiTi rotary files and randomly divided into two groups of 33 teeth each. Root canal obturation was carried out as the following: Group 1: Cold lateral condensation technique; Group 2: System B. The teeth were sectioned horizontally at 1, 2, 3, 4 mm from the working length. The total cross-sectional area of each canal was measured and the areas of gutta-percha, sealer and voids were calculated and converted to percentages of total surface area. Data were subjected to the Independent *t* test. At all levels, System B produced significantly higher gutta-percha filled areas ($P < 0.001$) and lower sealer and void-filled areas ($P < 0.001$) than lateral condensation technique. System B exhibited better complete obturation with minimal sealer thickness compared to cold lateral condensation.

Key words: PGFA, Cold lateral, System B

INTRODUCTION

Complete obturation of the root canal system with a dimensionally stable material is a major goal in conventional root canal therapy (Silver *et al*., 1999). Essentially two materials are used for root canals filling; one a semisolid material (gutta-percha), the other a sealing cement. Endodontic sealers play an important role in preventing leakage of root canal fillings, without which, the canals would leak (Kontakiotis *et al*., 1997; Wu *et al*., 2000). However, results of a 2-year in vitro follow-up study by Kontakiotis *et al*., (1997) showed that leakage along root fillings will eventually be enhanced by sealer dissolution. Consequently, the areas filled by sealer are more vulnerable because gutta-percha is dimensionally stable while the sealer can dissolve over time (Peters, 1986; Georgopoulou *et al*., 1995). Therefore, keeping a sealer restricted to a thin layer distributed uniformly around a solid mass of gutta-percha is preferred (Kontakiotis *et al*., 1997; Wu *et al*., 2000; De Deus *et al*., 2003). Based on these findings different root canal obturation techniques have been developed in order to achieve three-dimensional filling, such as the Schilder's technique (Schilder, 1967), System B (Buchanan, 1996), Thermafil system (Johnson, 1978) and injection moulded thermoplasticized gutta-percha (Yee *et al*., 1977). With all these techniques an endodontic sealer is recommended (De Moor and Hommez, 2002). The continuous wave of condensation technique (Buchanan, 1996) with System B heat source (Analytic Sybron Dental Specialities, Orange, CA, USA) was introduced to simplify vertical condensation (Kececi *et al*., 2005). The endodontic literature is replete with reports on root canal filling techniques that have been compared based on their leakage patterns. Recently, a number of articles have associated the gutta-percha-filled area (PGFA) with the method and quality of the filling technique (Silver *et al*., 1999; Eguchi *et al*., 1985; Ardila *et al*., 2003; De-Deus *et al*., 2006; Wu and Wesselink 2001; Wu *et al*., 2001; Wu *et al*., 2002). In these studies, the area of the entire canal, gutta-percha, sealer-filled area and voids were measured in cross-sections, and the percentage of filled area was calculated and an indication of the quality of the fill. The purpose of this study was to evaluate the percentage of the gutta-percha-filled area (PGFA) in the apical third of root canals when filled either with System B or lateral condensation.

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MATERIALS AND METHODS

Instrumentation:

Sixty six freshly extracted human maxillary central incisors were selected. Teeth with immature apices, previous root canal treatment, root fracture, restorations or caries were excluded from the study. Specimens were stored in 0.9% isotonic saline at room temperature. To facilitate instrumentation and eliminate variables in access preparation, the teeth were sectioned at the cemento-enamel junction. The working length was determined by introducing a size 10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) into the canal until it could be seen at the apical foramen. This length was measured and determined to be the working length minus 1 mm. The roots were prepared using ProTaper nickel titanium rotary files (Dentsply Maillefer) adhering to the complete sequence recommended by the manufacturer. The canals were irrigated between each file with 2 mL of 5.25% NaOCl. A size 10 hand K-file was introduced to maintain patency of the apical constriction. The canals were prepared to a F3 ProTaper file. After completion of the preparation all specimens were irrigated with 5 mL of 17% ethylene diamine tetra acetic acid (EDTA) for 60 s followed by 5 mL of 5.25% NaOCl for 60 s to remove the smear layer. Finally, the root canals were flushed with 2 ml of distilled water for 1 minute and dried with paper points (Dentsply/Maillefer).

Root Canal Filling:

The prepared roots were randomly assigned to two experimental groups of 33 teeth each (n=33). AH26 (Dentsply De Trey GmbH, Konstanz, Germany) was used as the root canal sealer for both filling techniques. The sealer was mixed according to the manufacturer's instruction and applied using a lentulo spiral.

Cold Lateral Compaction:

A size 30 gutta-percha cone was trimmed to give tugback at working length. After the sealer was placed in the canal with the Lentulo spiral, as described above, the apical one third of the master gutta-percha cone was coated with sealer and placed in the canal followed by insertion of a size 20 finger spreader, which was rotated and then withdrawn. An accessory gutta-percha cone, also coated with a thin layer of sealer, was placed in the space provided by the spreader. This process was repeated until the spreader could not penetrate more than 1–2 mm into the canal orifice. Excess gutta-percha was removed and condensed with a hot plugger.

Continuous Wave Condensation:

Obturation was carried as recommended by the manufacturer and according to Buchanan using the System B Heat Source (EIE/Analytic Technology, Orange, CA, USA) (Buchanan, 1996). The tip of a medium-sized non-standardized gutta-percha cone was trimmed back until tug-back was achieved at the working length. A medium plugger was marked at its binding point with a rubber stop within 5 mm of the working length. The System B unit was pre-set to 200 °C for the condensation of the primary gutta-percha cone (down-pack) and to 100°C for adapting and condensing the apical portion of the secondary (backfill) gutta-percha cone, and finally to 250°C to thermo-soften the remainder of the secondary cone prior to vertical condensation. After filling the root canals, radiographs were taken to assess the quality of the filling. The filling was considered satisfactory when no voids could be detected. In addition, the filling had to be 1mm short of the apical foramen. Teeth that did not meet these requirements were replaced. The filled roots were stored at 37°C and 100% humidity for seven days to allow for complete setting of the sealer.

Sectioning and Image Analysis:

The teeth were embedded in isobornyl methacrylate resin (Technovit 7200 VLC; EXAKT, Norderstedt, Germany) and sectioned horizontally with a 0.2 mm thick water-cooled diamond blade (EXAKT). Sectioning started at the apex and involved first the removal of 1mm of root at the apical foramen to reach the limit of the apical preparation, as the filling was 1mm short of the apex. Then, four subsequent sections each 1 mm thick were made. A digital photograph of the coronal surface of each consecutive section was obtained at 40x magnification using a stereomicroscope (Leica, Cambridge, UK). The cross-section area of the canal and its contents (gutta-percha, sealer and voids) were measured in square micrometers using Leica image analyzer software (Leica, Cambridge, UK). The areas of gutta-percha, sealer and voids were converted to percentages of the total area and gutta-percha filled area was then expressed in PGFA. The measurements obtained by image analysis were repeated twice to ensure reproducibility. Independent *t* test was used to compare the PGFAs at each observation level, 1, 2, 3 and 4 mm from the working length, by using SPSS software (SPSS INC, 2002, Chicago, USA version 12.0.1). Significance was determined at $P < 0.05$.

RESULTS AND DISCUSSION

For every section (1–4 mm), the means and standard deviations (in percentage) of the gutta-percha, sealer and voids areas of both cold lateral and System B obturation techniques are presented in Table 1. System B produced higher PGFAs at each observation level compared to the cold lateral technique ($P < 0.001$). Both groups clearly demonstrated that the area of sealer decreased coronally, while that of gutta-percha increased. At each level, sealer and voids areas were significantly fewer with the System B obturation technique than cold lateral condensation technique ($P < 0.001$). Figures 1-4 demonstrate representative cross-sections of the two groups

Table 1: PGFA, sealer area and voids (in %) at each level 1-4 mm from the apex

Sections		Cold Lateral (*n*= 33)		System B (*n*= 33)	
		Mean%	SD	Mean%	SD
1 mm	PGFA	80.75	2.99	89.77	1.81
	Sealer	15.57	1.14	5.82	1.22
	Voids	4.05	.76	2.59	.82
2 mm	PGFA	83.21	1.21	95.33	1.27
	Sealer	12.34	1.08	3.79	.99
	Voids	4.84	1.55	.93	.47
3 mm	PGFA	86.25	1.65	98.05	1.29
	Sealer	12.73	1.94	2.23	1.03
	Voids	2.05	.71	.04	.12
4 mm	PGFA	87.87	1.20	98.99	.83
	Sealer	10.35	.97	.33	.53
	Voids	1.99	.98	.01	.02

PGFA: gutta-percha filled area
SD= standard deviation

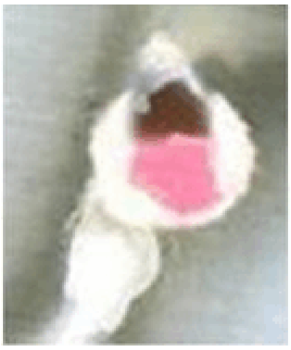

Fig. 1: Cold lateral at 1 mm from the apex

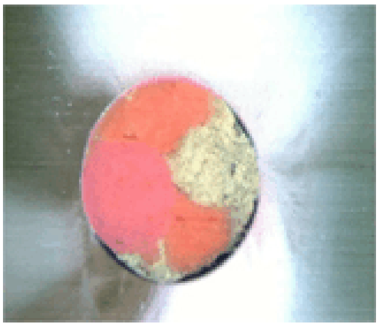

Fig. 3: System B at 1 mm from the apex

Fig. 2: System B at 4 mm from the apex

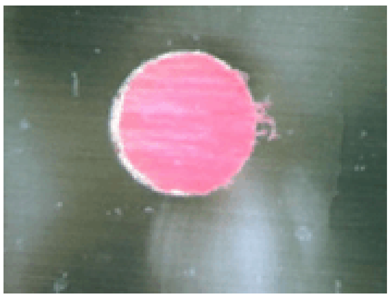

Fig 4: Cold lateral at 4 mm from the apex

Discussion:

The solubility of endodontic sealers is probably responsible for the increase in leakage along the root fillings over time (Kontakiotis *et al*., 1997), therefore the reduced ratio of sealer to gutta-percha may improve the long term seal provided by root canal fillings. Thus, the goal of various root filling techniques is to maximize the amount of gutta-percha and minimize the amount of sealer. Consequently, several studies have been done comparing the root canal filling quality by calculating the percentage of gutta-percha, voids and sealer (Silver *et al*., 1999; Kontakiotis *et al*., 1997; Wu *et al*., 2000; Eguchi *et al*., 1985; De-Deus *et al*., 2006; Wu *et al*., 2001; Wu *et al*., 2002; Cathro and Love, 2003).

Cold lateral compaction of gutta-percha is the most widely accepted and used obturation technique in endodontics (Dummer, 1991; Peak *et al*., 2001). However, this technique can result in the creation of voids, excessive amounts of sealer (Eguchi *et al*., 1985; Brayton *at al*., 1973), and lack of adaptation to the surface of the prepared root canal (Chu *et al*., 2005). Therefore, alternative techniques have been introduced which incorporate the use of thermal or frictional heat to plasticize the gutta-percha, allowing for better adaptation to canal walls and a higher degree of homogeneity (Schilder, 1967). The continuous wave condensation technique was chosen for this study, as a number of advantages have been reported in the literature (Buchanan, 1996; McRobert and Lumley, 1997). This technique has been found superior to some other canal filling techniques in terms of apical leakage (DuLac *et al*., 1999; Pommel and Camps, 2001; Farea *et al*., 2010) and procedural time (Silver *et al*., 1999; Buchanan, 1996; Kececi *et al*., 2005).

In the present study, the root canals filled by continuous wave condensation technique contained significantly higher gutta-percha with lower sealer volume at all levels than those obturated by lateral condensation technique. Silver *et al*., (1999) reported that System B produced root fillings consisting of over 90% gutta-percha. moreover, Cathro et al. compared the proportion of gutta-percha, sealer and voids following the filling of simulated root canals in plastic blocks using MicroSeal and System B/Obtura II techniques and found that System B/Obtura II produced a homogeneous fill with average of 99.27% of gutta-percha and no voids at all levels compared to that produced by MicroSeal (Cathro and Love, 2003). Wu *et al*., (2001) concluded that higher percentage of gutta-percha-filled canal area was produced using warm vertical condensation than that of the cold lateral condensation in oval canals. Moreover, Eguchi *et al*., (1985) reported that lateral condensation produced the smallest amount of gutta-percha at 2 and 4 mm distance from the apex (78.4% and 80.8%, respectively), indicating a greater cement component. Gencoglu *et al*., (2002) found that Thermafil, JS Quick-Fill and System B were superior to the lateral condensation technique in terms of core/sealer ratio which may related to the higher dye leakage detected with lateral condensation technique. However, our results in disagreement with De-Deus *et al*., (2007) and Kececi *et al*., (2005) who found no significant difference between System B and lateral condensation in term of GPFAs.

An interesting finding in this study was that no apical extrusion of gutta-percha was seen when continuous wave condensation technique was used (data not shown). Similar findings were observed in previous studies (Silver *et al*., 1999; Bowman and Baumgartner, 2002). This probably was due to the preserving of apical constriction while shaping the root canal and the use of a prefitted master cone. Another possible explanation is that gutta-percha in the most apical part of the root canal was not heated. System B plugger should be selected to fit within 5-7 mm from the root canal termini as recommended by the manufacturer. However Smith et al reported that System B produced better results when the plugger was placed within 3 mm of the working length (Smith *et al*., 2000). In the present study, the plugger was set at 5 mm of the working length and this may affect the performance of System B in the most apical root canal. Thus, relatively low PGFAs with more voids and thicker layer of sealer were achieved by the continuous wave condensation at 1 mm from the working length compared to the other levels, which may be an indication that the most apical gutta-percha was not heated sufficiently.

Maxillary central incisors were selected for this study to minimize anatomical variation and allow standardization. In addition, all the canals were prepared to the same final apical size. Further study is needed to determine whether same results can be achieved when posterior teeth with more complex anatomy are used.

Conclusion:

Within the limitations of this study it can be concluded that System B produced significantly higher PGFAs than the lateral condensation technique (P < 0.01). The results favor the use of System B for a better and homogenous obturation of the root canal with a minimal amount of sealer.

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REFERENCES

Ardila, C.N., M.K. Wu, P.R. Wesselink, 2003. Percentage of filled canal area in mandibular molars after conventional root canal instrumentation and after a non-instrumentation technique (NIT). Int Endod J. 36: 591-8.

Bowman, C.J. & J.C. Baumgartner, 2002. Gutta-percha obturation of lateral grooves and depressions. J Endod., 28: 220-3.

Brayton, S.M., S.R. Davis, M. Goldman, 1973. Gutta-percha root canal fillings. Oral Surg Oral Med Oral Pathol., 35: 226-31.

Buchanan, L.S., 1996. The continuous wave of condensation: centered condensation of gutta-percha in 12 seconds. Dent Today., 15: 60-7.

Cathro, P.R. & R.M. Love, 2003. Comparison of MicroSeal and System B/Obtura II obturation techniques. Int Endod J. 36: 876-82.

Chu, C.H., E.C.M. Lo, G.S.P. Cheung, 2005. Outcome of root canal treatment using Thermafil and cold lateral condensation techniques. Int Endod J. 38: 179-85.

De-Deus, G.A., E.D. Gurgel-Filho, K.M. Magalhães, T. Coutinho-Filho, 2006. A laboratory analysis of gutta-percha-filled area obtained using Thermafil, System B and lateral condensation. Int Endod J. 39: 378-83.

De-Deus, G., C.M. Maniglia-Ferreira, E.D. Gurgel-Filho, S. Paciornik, A.C. Machado, T. Coutinho-Filho, 2007. Comparison of the percentage of gutta-percha-filled area obtained by Thermafil and System B. Aust Endod J. 33: 55-61.

De Deus, G.A., F. Martins, A.C. Lima, E.D. Gurgel-Filho, C.F. Maniglia, T. Coutinho-Filho, 2003. Analysis of the film thickness of a root canal sealer following three obturation techniques. Pesqui Odontol Bras., 17: 119-25.

De Moor, R.J.G., G.M.G. Hommez, 2002. The long term sealing ability of an epoxy resin root canal sealer used with five gutta percha obturation techniques. Int Endod J. 35: 275-82.

DuLac, K.A., C.J. Nielsen, T.J. Tomazic, P.J. Ferrillo Jr, J.F. Hatton, 1999. Comparison of the obturation of lateral canals by six techniques. Int Endod J. 25: 376-80.

Dummer, P.M., 1991. Comparison of undergraduate endodontic teaching programmes in the United Kingdom and in some dental schools in Europe and the United States. Int Endod J. 24: 169-77.

Eguchi, D.E., D.D. Peters, J.O. Hollinger, L.A. Lorton, 1985. Comparison of the area of the canal space occupied by gutta-percha following four gutta-percha obturation techniques using Procosol sealer. J Endod., 11: 166-75.

Farea, M, S. Masudi, W.Z. Wan Bakar, 2001. Apical microleakage evaluation of system B compared with cold lateral technique: In vitro study. Aust Endod J., 36: 48-53.

Gencoglu, N., Y. Garip, M. Bas, & S. Samani, 2002. Comparison of different gutta-percha root filling techniques: Thermafil, Quick-fill, System B, and lateral condensation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod., 93: 333-6.

Georgopoulou, M.K., M.K. Wu, A. Nikolaou, P.R. Wesselink, 1995. Effect of thickness on the sealing ability of some root canal sealers. Oral Surg Oral Med Oral Pathol Oral Radiol Endod., 80: 338-44.

Johnson, W.B., 1978. A new gutta-percha technique. J Endod., 4: 184–8.

Kececi, A.D., G.C. Unal, B.H. Sen, 2005. Comparison of cold lateral compaction and continuous wave of obturation techniques following manual or rotary instrumentation. Int Endod J. 38: 381-8.

Kontakiotis, E.G., M.K. Wu, P.R. Wesselink, 1997. Effect of sealer thickness on long-term sealing ability: a 2-year follow-up study. Int Endod J. 30: 307-12.

McRobert, A.S., P.J. Lumley, 1997. An in vitro investigation of coronal leakage with three GP backfilling techniques. Int Endod J. 30: 413-7.

Peak, J.D., S.J. Hayes, S.T. Bryant, P.M. Dummer, 2001. The outcome of root canal treatment. A retrospective study within the armed forces (Royal Air Force). Br Dent J. 190: 140-4.

Peters, D.D., 1986. Two years in vitro solubility evaluation of four gutta-percha sealer obturation techniques. J Endod., 12: 139-45.

Pommel, L., J. Camps, 2001. In vitro apical leakage of System B compared with other filling techniques. J Endod., 27: 449-51.

Schilder, H., 1967. Filling root canals in three dimensions. Dent Clin North Am. 11: 723-44.

Silver, G.K., R.M. Love, D.G. Purton, 1999. Comparison of two vertical condensation obturation techniques: Touch 'n Heat modified and System B. Int Endod J. 32: 287-95.

Smith, R.S., R.N. Weller, R.J. Loushine, & W.F. Kimbrough, 2000. Effect of varying the depth of heat application on the adaptability of gutta-percha during warm vertical compaction. J Endod., 26: 668-72.

Wu, M.K., A. Kast'akova, P.R. Wesselink, 2001. Quality of cold and warm gutta-percha fillings in oval canals in mandibular premolars. Int Endod J. 34: 485-91.

Wu, M.K., A.R. Ozok, P.R. Wesselink, 2000. Sealer distribution in root canals obturated by three techniques. Int Endod J. 33: 340-5.

Wu, M.K., B. Van, P.R. Wesselink, 2000. Diminished leakage along root canals filled with gutta percha without sealer over time: a laboratory study. Int Endod J. 33: 121-5.

Wu, M.K., van der L.W.M. Sluis, P.R. Wesselink, 2002. A preliminary study of the percentage of gutta-percha filled area in the apical canal filled with vertically compacted warm guttapercha. Int Endod J. 35: 527-35.

Wu, M.K., P.R. Wesselink, 2001. A primary observation on the preparation and obturation of oval canals. Int Endod J. 34: 137-41.

Yee, F.S., J. Marlin, A.A. Krakow, P. Grøn, 1977. Three-dimensional obturation of the root canal injection molded, thermoplasticized dental gutta-percha. J Endod., 3: 168-74.