Comparison of cold lateral compaction and continuous wave of obturation techniques following manual or rotary instrumentation

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Abstract

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Aim To compare different combinations of root canal preparation and obturation technique.

Methodology A total of 48 freshly extracted human maxillary central incisors were divided into two identical groups on the basis of root canal length and apical diameter. The root canals were prepared by manual crown-down pressureless technique or with a rotary system (ProFile; Dentsply Maillefer, Ballaigues, Switzerland) in a crown-down technique. The coronal diameter and apical size of the root canals were standardized in both preparation techniques. Each main group was then divided into two subgroups and obturated with either cold lateral compaction or continuous wave of obturation with System B (EIE-Analytic Technology, Orange, CA, USA). The distribution of filling material in each canal was assessed by stereomicroscopic examination of eight cross-sections on each tooth. Areas of sealer, gutta-percha and voids were measured on the digital images of a total of 384 samples. Manipulation time and apical extrusion for each group was also determined. Data were statistically analysed using Kruskal–Wallis, ANOVA (Bonferroni/Dunn) or Student's t-test.

Results The percentage of sealer, gutta-percha and voids area between the obturation techniques was not significantly different ($P > 0.05$). Continuous wave groups had significantly more apical extrusion of sealer ($P < 0.05$), while none of the obturation techniques had gutta-percha extrusion. Rotary instrumentation was significantly faster than the manual technique ($P < 0.05$); continuous wave obturation was significantly faster than lateral compaction ($P < 0.05$). Total manipulation time in the rotary/continuous wave group was significantly shorter than the other groups ($P < 0.0001$).

Conclusion The distribution of filling materials was similar in all combinations of instrumentation and obturation techniques. The continuous wave technique was faster than lateral compaction and it extruded more sealer.

Keywords: obturation, ProFile, root canal instrumentation, System B.

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Introduction

The purpose of root canal obturation is to place an inert filling material in the space previously occupied by pulp tissue (Wesselink 1990). A maximum volume of gutta-percha and a thin layer of sealer are preferred because sealer may shrink during setting and dissolve, thus causing leakage (Kontakiotis *et al.* 1997, DuLac *et al.* 1999).

Recently, rotary systems have been introduced and recommended particularly for the preparation of curved root canals (Kavanagh & Lumley 1998, Bryant *et al.* 1999). Many studies suggest that root canal preparation with nickel-titanium rotary files produces a

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more consistent, uniform, centred and round canal form (Glosson *et al.* 1995, Thompson & Dummer 1997). However, studies have also shown superior results when using hand instrumentation for creating a well-shaped root canal (Hülsmann & Stryga 1993, Hülsmann *et al.* 1997).

Even though cold lateral compaction is preferred as a standard obturation technique in many studies (Hopkins *et al.* 1986, Gilhooly *et al.* 2000, Cathro & Love 2003), it is not known whether the root canal preparation technique has any effect on the quality of root filling (von Fraunhofer *et al.* 2000). 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. Some studies have reported comparable results of this technique to other filling techniques (Silver *et al.* 1999, Cathro & Love 2003).

A variety of techniques have been used to evaluate the quality of root fillings including leakage tests (Pathomvanich & Edmunds 1996, Davalou *et al.* 1999, Wu *et al.* 2000a), radiographic comparisons (Lambrianidis 1985, Kersten *et al.* 1987, Gutmann *et al.* 1993), microscopic evaluations (DuLac *et al.* 1999) or cross-sections (Wu *et al.* 2001).

The objectives of this study were to compare four different variations of preparation and filling techniques in terms of percentage total area of filling materials, apical extrusion and manipulation time, and to determine if the preparation technique influenced the quality of filling.

Materials and methods

Forty-eight human maxillary central incisors extracted for periodontal reasons were selected. Debris on root surfaces was removed and conventional access cavities were prepared using a size 012 round diamond bur in a high-speed water-cooled handpiece. The teeth were divided into two identical groups on the basis of the following criteria: no resorption or fracture, fully formed apices, single root canal patent to sizes 15–30 file and same working length (some teeth were shortened to a standard tooth length of 22 mm).

Root canals were prepared by one operator using a manual crown-down pressureless technique or a rotary system (ProFile; Dentsply Maillefer, Ballaigues, Switzerland) with a crown-down technique. The coronal (size 80) and apical size (size 45) of root canals were standardized in both of the preparation techniques. Each main group was then divided randomly into two subgroups of 12 teeth and filled with cold lateral compaction or continuous wave of condensation techniques.

Manual crown-down preparation

Twenty-four teeth (groups 1 and 2) were prepared manually using a crown-down pressureless technique with K-Flex files (Kerr, Romulus, MI, USA) according to Morgan & Montgomery (1984). A size 15 K-Flex file was introduced to the main foramen to assure apical patency and then withdrawn 1.0 mm to establish working length at 21 mm for each tooth. Gates-Glidden burs (sizes 2–6) were used to enlarge the coronal 2/3 of the root canals; then K-Flex files were used until the apical diameter was size 45. Each hand file was coated with 0.1 mL of 19% EDTA gel (File-Eze; Ultradent, Salt Lake City, UT, USA).

After each instrument, the root canals were irrigated with 1 mL of 2.5% sodium hypochlorite. The total volume of irrigant was 12 mL.

Rotary crown-down preparation

Twenty-four teeth (groups 3 and 4) were prepared with ISO sized ProFile nickel-titanium rotary instruments using a 16 : 1 reduction handpiece powered by an electric motor (NT Company, Chattanooga, TN, USA) with a constant speed of 175 rpm (Table 1). An identical irrigation technique and volume were used.

Root canal filling

Sealapex (Kerr, Romulus, MI, USA) was used as the root canal sealer for both filling techniques. The sealer

Table 1 Sequence of rotary instrumentation

	Size	Taper	Usage of direction (mm)
Coronal 1/3 canal	80	.08	14
	60	.08	15
	50	.07	16
Coronal 2/3 canal	40	.06	17
	30	.06	18
	25	.06	19
Apical 1/3 canal	30	.04	20
	25	.04	21
	30	.04	21
	35	.04	21
	40	.04	21
	45	.04	21

was mixed according to the manufacturer's instrumentation. A size 40 K-file (Dentsply Maillefer) was used to place the same volume of the sealer into each root canal at the working length.

Cold lateral compaction

Twenty-four teeth (groups 1 and 3) were obturated by lateral compaction of gutta-percha. The apical section of a size 45 gutta-percha cone was coated with a thin film of sealer and placed into the canal at full working length. A size C spreader (Dentsply Maillefer) was selected for lateral compaction that reached 1–2 mm short of the working length. Auxiliary size 25 points coated with sealer were placed in the voids created by the spreader. This was repeated until the spreader could not penetrate more than 1–2 mm into the canal orifice. Excess gutta-percha was removed with gutta-cut (Dentouch, Tel Aviv, Israel).

Continuous wave of condensation

Twenty-four teeth (groups 2 and 4) were filled with the continuous wave of condensation technique (Buchanan 1996, McRobert & Lumley 1997) using the System B Heat Source (EIE/Analytic Technology, Orange, CA, USA). Continuous wave obturation was carried out in two steps. First, a medium-sized gutta-percha cone (Analytic Technology) was placed in the apical third of the root canal. The gutta-percha was adjusted with a scalpel 1 mm short of working length until tug-back was achieved. A System B medium-sized plugger was marked at its binding point with a rubber stop within 4 mm of working length. After coating the root canal walls with sealer, the apical

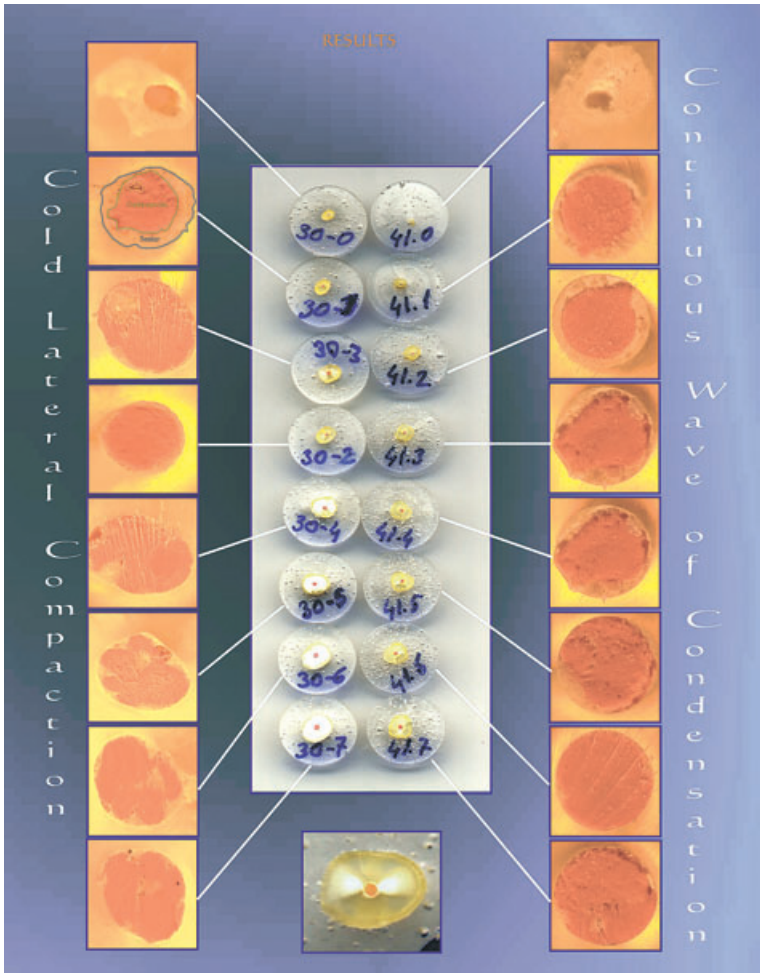

Figure 1 Stereomicroscopic view of cross-sections of two different obturation techniques (×4 or ×10 magnification). Note the non-homogenous view of gutta-percha in upper sections of the canals obturated with lateral compaction. In contrast, most of the continuous wave groups showed homogenous gutta-percha mass.

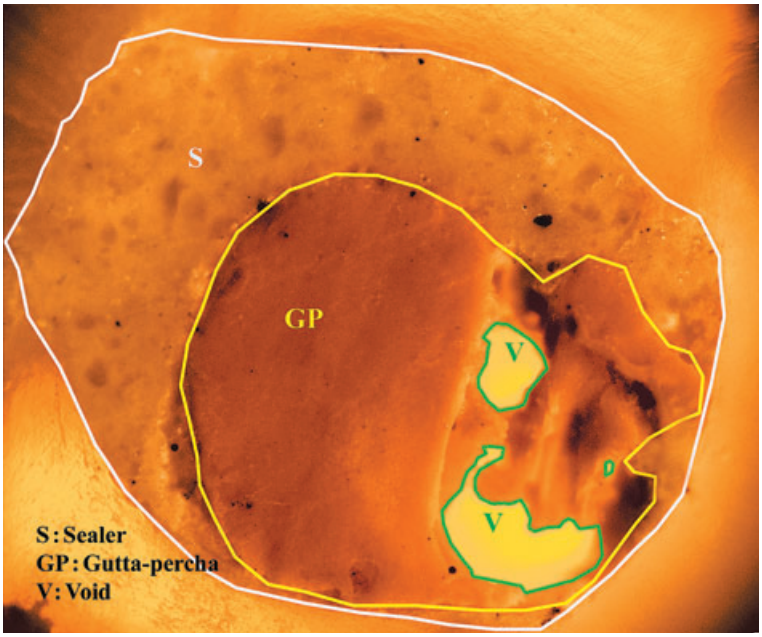

Figure 2 Borders of sealer, gutta-percha and voids on a cross-section image.

part of master cone was coated with a thin film of sealer and placed into the canal. The heat source was adjusted to 200 °C at full power and touch mode was activated. The heated plugger was driven through the gutta-percha to approximately 3–4 mm before the rubber stop approached the reference point. During the downpack the plugger was moved apically slowly. The plugger was then deactivated, and firm apical pressure held for 10 s. After this downpacking procedure backfilling was completed.

A backfilling gutta-percha point corresponding to the size of the master cone was selected and trimmed until tug-back was achieved. The System B plugger was reintroduced at a reduced temperature of 100 °C activated for 1 s and placed to half its previous depth in the canal, the backfilling points were stabilized as necessary and the System B plugger was removed. The temperature setting was increased to 250 °C; the coronal gutta-percha heated for 1–2 s and condensed using the plugger.

Assessment

Manipulation time

The preparation and filling time for each tooth were recorded in minutes and seconds. The sum of both values indicated the total manipulation time for a specific combination of preparation and filling technique. Manipulation time included the irrigation procedures but not the preliminary preparation of instruments and devices.

Apical extrusion

The extrusion of sealer and/or gutta-percha through the apical foramen was recorded using a yes/no scheme.

Cross-sections and microscopic measurements

Following obturation the coronal access cavities were restored with polycarboxylate cement (Poly-F Plus; Dentsply International, York, PA, USA) and teeth placed in saline solution for 1 week in order to ensure complete setting of the sealer. The teeth were embedded in epoxy resin blocks (Orthoacril; Dentarium, Ispringen, Germany) and sectioned horizontally with a 0.1 mm-thick and 25 mm-radius disc (Meisinger 232, Neuss, Germany) at 35 000 rpm under water-cooling. The first section was made 0.5 mm from the apex; then, seven subsequent sections were made at 1-mm intervals (1.5, 2.5, 3.5, 4.5, 5.5, 6.5 and 7.5 mm, respectively) (Fig. 1).

After sectioning, each of the eight horizontal segments (384 samples) was digitally viewed at ×4 or ×10 magnification with a stereomicroscope (Zeiss Axioskop 2, Munich, Germany). The borders of sealer, gutta-percha and voids could be distinguished clearly by means of their different colours. Sealer was white, gutta-percha was orange and voids were yellow. On the

digital image of each horizontal segment, the total area of each canal section and the areas of its contents (sealer, gutta-percha, voids) were measured in a metric system using a PC software program (AutoCAD 2000, San Rafael, CA, USA) (Fig. 2). The area of sealer, gutta-percha and voids were converted to percentages of the total area.

Statistical analysis

The average area values of each section for each filling component were compared for the four groups. Data were analysed using Kruskal–Wallis tests. Apical extrusion in lateral compaction vs. continuous wave technique was compared using the Student's *t*-test. The Student's *t*-test was used to compare the main groups (manual vs. rotary crown-down preparation technique; lateral compaction vs. continuous wave technique) for manipulation time, and the Bonferroni/Dunn test was used to compare subgroups (groups 1–4).

Results

Distribution of sealer, gutta-percha and voids

No significant differences were found between the groups in terms of distribution of sealer, gutta-percha and voids at any level (Table 2). In all groups, it was obvious that the area of sealer decreased coronally while that of gutta-percha increased. The total area of gutta-percha was not statistically different among the

Table 2 Mean and range values of gutta-percha, sealer and voids ratio in each section of four groups (%) (group 1: manual crown-down + lateral compaction, group 2: manual crown-down + continuous wave, group 3: rotary crown-down + lateral compaction, group 4: rotary crown-down + continuous wave techniques)

	Group 1		Group 2		Group 3		Group 4	
Sections	Mean	Range	Mean	Range	Mean	Range	Mean	Range
0.5 mm								
Gutta-percha	43.43	0.00–85.81	36.89	0–90.33	49.75	0–80.97	30.24	0–90.10
Sealer	56.57	14.19–100	62.46	9.67–100	54.11	19.03–100	69.76	9.90–100
Voids	0.00	0.00–0.00	0.63	0.00–6.83	0.66	0.00–7.29	0.00	0.00–0.00
1.5 mm								
Gutta-percha	53.18	0–84.68	42.31	0–79.85	61.98	21.05–77.58	61.98	0–88.2
Sealer	45.94	15.32–100	57.69	20.15–100	38.59	22.42–78.50	38.02	11.80–100
Voids	0.86	0.00–10.32	0.00	0.00–0.00	0.08	0.00–1.05	0.00	0.00–0.00
2.5 mm								
Gutta-percha	77.03	0.00–93.61	62.61	42.68–91.81	72.31	61.40–82.93	71.46	33.47–100
Sealer	22.97	6.39–36.87	37.63	8.19–57.32	27.51	17.07–39.31	28.54	0.00–66.53
Voids	0.00	0.00–0.00	0.03	0.00–0.47	0.18	0.00–2.17	0.00	0.00–0.00
3.5 mm								
Gutta-percha	78.42	68.19–94.82	81.43	43.58–95.06	75.26	46.74–95.18	72.78	32.38–99.21
Sealer	21.59	5.18–32.64	31.15	4.94–56.42	23.88	4.82–43.01	27.22	0.79–67.62
Voids	0.29	0.00–3.43	0.00	0.00–0.00	0.85	0.00–10.25	0.00	0.00–0.00
4.5 mm								
Gutta-percha	73.31	34.30–92.76	75.88	54.76–95.58	75.47	56.90–97.48	72.89	26.90–91.04
Sealer	21.53	7.24–65.70	23.78	4.42–41.13	24.10	2.52–43.10	26.83	8.96–69.82
Voids	0.16	0.00–1.96	0.34	0.00–4.11	0.00	0.00–0.00	0.27	0.00–3.28
5.5 mm								
Gutta-percha	83.41	74.14–99.93	75.38	44.77–93.41	79.58	50.73–95.13	73.80	54.00–89.86
Sealer	16.58	0.07–27.70	20.90	6.59–35.36	20.42	4.87–49.27	24.08	10.14–37.56
Voids	0.16	0.00–1.95	3.71	0.00–20.69	0.00	0.00–0.00	2.12	0.00–12.03
6.5 mm								
Gutta-percha	84.35	65.75–96.49	74.51	33.07–100	81.94	68.53–96.80	80.24	61.24–92.31
Sealer	15.40	3.51–34.25	22.16	0.00–47.51	17.27	3.20–26.21	18.00	7.69–34.61
Voids	0.24	0.00–1.47	3.33	0.00–19.42	0.87	0.00–9.53	1.92	0.00–13.05
7.5 mm								
Gutta-percha	81.07	50.70–95.39	86.73	58.74–100	81.23	62.43–96.17	83.07	53.76–96.69
Sealer	18.93	4.61–49.30	11.50	0.00–41.26	18.03	3.83–39.38	14.28	1.19–40.05
Voids	0.00	0.00–0.00	0.76	0.00–6.04	0.81	0.00–8.12	2.32	0.00–15.02

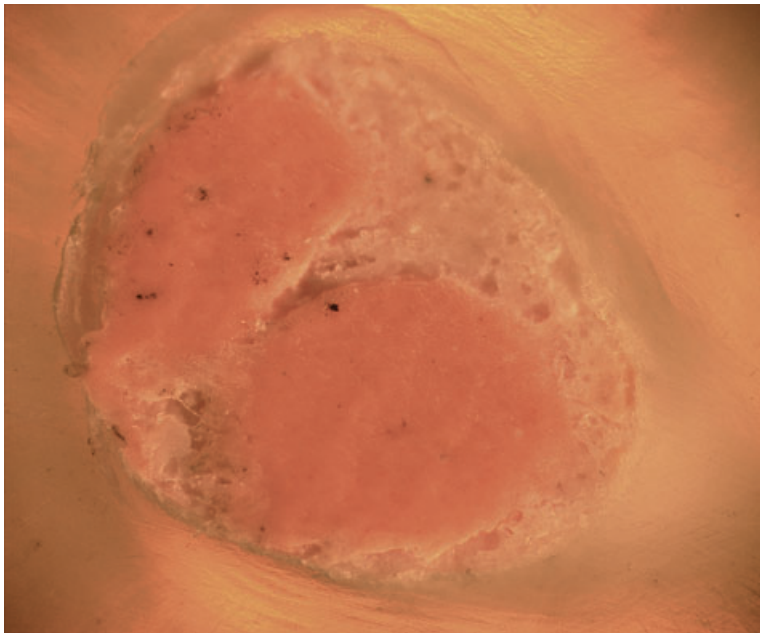

Figure 3 In some 3.5 and 4.5 mm cross-sections of continuous wave fills, the apical gutta-percha point did not blend with the backfilling points.

groups ($P > 0.05$). On the contrary, it was observed that gutta-percha had more homogeneous view in most of the samples of continuous wave groups (Fig. 1). Only in some cross-sections, the master gutta-percha point was observed not to have blended with the backfilling points (Fig. 3).

Manipulation time

The mean time required for preparation with the manual crown-down technique was 14 min 21 s and 8 min 55 s with rotary instrumentation. Mean obturation time was 4 min 12 s for lateral compaction and 2 min 32 s for continuous wave of obturation. The rotary crown-down technique and continuous wave technique were significantly faster than the others ($P < 0.05$). When the subgroups were compared, the time required for group 1 (step-back + lateral compaction) was statistically greater than the other groups ($P < 0.0001$) (Table 3).

Table 3 Mean values (min:s) ± standard deviations of manipulation time in the groups

Group	Preparation time	Obturation time	Total manipulation time
1	16:49 ± 5.08*	4:21 ± 0.33**	20:70 ± 5.07***
2	12:12 ± 2.10*	2:04 ± 0.20	14:16 ± 2.15
3	9:23 ± 2.24	4:04 ± 0.39**	13:27 ± 2.13
4	9:33 ± 3.71	2:23 ± 0.37	11:56 ± 4.06

*$P < 0.05$ (Student's *t*-test), **$P < 0.01$ (Student's *t*-test), ***$P < 0.0001$ (Bonferroni/Dunn).

Apical extrusion

No apical extrusion of sealer was observed in lateral compaction groups (groups 1 and 3), while a high prevalence of sealer extrusion was observed in the continuous wave groups: 10 teeth in group 2, (83%) and nine teeth in group 4 (75%). The difference between lateral compaction and continuous wave was significant ($P < 0.05$).

Discussion

Manual and rotary instrumentations, both used in a crown-down manner were selected for this study. The techniques had been practiced extensively beforehand and all specimens were prepared and filled by one operator to reduce variability. In order to reduce the possibility of deformation or fracture, each instrument was used to prepare only five root canals. In recent years, rotary instrumentation with nickel-titanium files has been shown to create smooth, funnel shapes, with minimal risk of ledging or transporting and in less time (Short *et al.* 1997). On the contrary, conventional hand instrumentation techniques are known to be time-consuming (Glosson *et al.* 1995, Short *et al.* 1997, Rhodes *et al.* 2000).

The continuous wave of obturation technique was chosen for this study, as a number of advantages have

been reported (Buchanan 1996, McRobert & Lumley 1997). This technique has been found superior to some other canal filling techniques in terms of apical leakage and procedural time (Buchanan 1996, DuLac *et al.* 1999). The mean time to fill canals with System B in the study by Silver *et al.* (1999) (1 min 3 s) and in the present study (2 min 24 s) was much greater than the time (12 s) reported by Buchanan (1996), but substantially less than lateral compaction. Lateral compaction is commonly used as the control obturation technique in research studies of root canal filling techniques.

One of the objectives of the comparisons of different preparation–filling combinations used in this study was to determine whether the preparation technique influences the quality of filling. Within the limitations of this study, no significant relationship was found between the preparation and obturation techniques. A similar study comparing the quality of cold lateral compaction following canal preparation using endosonic or hand instrumentation also reported no significance between the canal areas of the sealer, gutta-percha and voids (Nattress *et al.* 1994).

In the present study, the distribution of gutta-percha did not achieve 90% as reported by Silver *et al.* (1999) and Wu *et al.* (2001) used the continuous wave of condensation technique. Similarly, Wu *et al.* (2001) found that the apical gutta-percha ratio was low in some specimens and the sealer thickness was high. The insufficient softening of the gutta-percha by heat was thought to be responsible for low gutta-percha adaptation. In some studies the sealer rates (42–63%) were higher than reported in the present study (Hall *et al.* 1996, Wu *et al.* 2000b). Of course, the outcome of the filling procedures used depends on the application power, amount of sealer and its physical properties of flow and film thickness (Ørstavik 1982, Oguntebi & Shen 1992, Wu *et al.* 1997, 2000b).

The continuous wave of condensation groups showed 79.16% apical extrusion of sealer but no extrusion of gutta-percha. The clinical importance of overfilling is not only due to material irritation, but also due to lack of an apical seal (Seltzer *et al.* 1973, Walton & Johnson 1996). Large volume of sealer at the apex leads to apical leakage in longer periods (Pommel & Camps 2001). In this study, similar sealer distributions of all groups showed that both obturation techniques may have the same risk of apical leakage in the long term.

Conclusions

1. No statistical differences were found between any of the preparation/filling combinations in terms of distribution of sealer, gutta-percha or voids.
2. Distribution of filling material was not influenced by preparation technique.
3. The continuous wave of obturation resulted in significantly more apical extrusion of sealer.

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