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Comparative evaluation of sealing ability of 3 different Obturation methods in severely curved root canals

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ABSTRACT

The aim of this study was to evaluate the obturation quality in severely curved canals. Thirty-six root canals (angle of curvature > 35^{o}) were used. They were instrumented to 35/.04 BioRaCe, and were divided into 3 groups: lateral compaction, System B/ Obtura, Thermafil. Roots were sectioned at 0mm, 3mm and 5 mm from working length and observed in stereomicroscope (x6). Total area of voids and the maximum penetration of filling materials in isthmuses were measured with image J. For statistical analysis One-Way ANOVA, Kruskal Wallis and Wilcoxon tests were used. There was no statistically significant difference in the total area of voids among groups. Cross-section at 0 mm produced higher total area of voids than cross-section at 5 mm. Penetration of filling materials into isthmuses was deeper in System B/ Obtura. All the examined methods exhibited similar obturation quality, though material with System B/ Obtura penetrated deeper into isthmuses.

Keywords: BioRaCe, isthmus, obturation, stereomicroscope, voids.

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INTRODUCTION

The purpose of endodontic treatment is the establishment or maintenance of health of periapical tissues. Chemomechanical preparation reduces bacteria population inside the infected root canal system. Whereas, obturation is performed: a) to create a hostile environment for bacteria that survive chemomechanical procedure, b) to prevent coronal micro leakage and bacterial re-infection, and c) to prevent accumulation of fluids from the periapical tissues into the root canal system (1). Many techniques have been proposed in order to obtain hermetic sealing of the root canal system. Lateral condensation, warm vertical or lateral compaction, thermomechanical compaction, continuous wave obturation, thermoplastic injection and carrier-based techniques are a few of them.

In order to evaluate in vitro the sealing ability of these techniques, either microleakage studies or observational methods have been performed (2). The first category includes passive and dynamic methods, where no visual observation of filling materials is possible. On the other hand, in observational studies, direct evaluation of the filling materials and the root canal can be performed in destructive and non-destructive ways. In destructive methods, samples are sectioned horizontally or longitudely (split tooth model) (3) and the sections can be observed through an optical microscope or a stereomicroscope (4). With these methods it is possible to observe materials inside the instrumented root canal, to examine the position and size of remaining voids and their relationship to the filling materials. Scanning electron microscopy also belongs to destructive methods, and is used to study the interface of materials and root canal wall (5). More recently, the non-destructive methods microcomputed tomography (μ-CT) and nano-CT analysis have been introduced to evaluate the quality of root canal obturation (6,7).

Although scientific research in the field of root canal obturation is extended (8), very few studies deal with the sealing ability of obturation techniques in severely curved root canals. So, the aim of this study was the evaluation of the sealing ability in severely curved canals of 3 different obturation techniques (System B, Thermafil, lateral condensation) using optical microscopy. For this purpose, total area of voids that remained after obturation was recorded and the maximum penetration depth of the obturation material inside isthmuses was measured.

MATERIAL AND METHOD

Tooth selection

For this study freshly extracted mature mandibular molars with separate roots, already extracted for other reasons, were used. Teeth throughout the experimental procedure were kept in saline. For the removal of the organic material, teeth were placed in 5, 25% NaOCl for 2 hours and root scaling was followed. The crown of each tooth was removed using a diamond disk at the level of the cement enamel junction. Also, mesial roots were separated from distal and the latter were rejected.

The external surface of mesial roots was examined under optical microscope for cracks, fractures or root resorption. Then, if devoid of any of the above, it was placed in a radiographic mount made of a silicone-based impression to maintain a constant position at mesio-distal and bucco-lingual direction. Bucco-lingual radiographs were used to estimate Schneider's angle of curvature. Only roots whose angle of curvature ranges was greater than 35° were included. Mesio-distal radiographs were used to control if each root contained separated root canals. In case of separate canals both were used for the study. If they merged only one was included.

Thirty mesial roots corresponding to 36 independent root canals were selected for this study.

Root canal preparation

Patency was obtained with a 10 k-file. Not patent root canals were excluded from the study. Working length was set by measuring the length of the file exiting the apical foramen withdrawn by 1 mm. All canals were enlarged in the following sequence of BioRaCe instruments (BioRaCe; FKG Dentaire, La Chaux-de-Fonds, Switzerland) using torque $1N/cm^2$ and speed 500rpm: 10 K file, 15 K file, BR0, BR1, BR2, BR3, BR4C, BR4. MAF was set at BR4 (35/.04). All instruments were used to full WL except for BR 0. After each instrument, the canals were flushed with 2 ml of 3% NaOCl using a 30-gauge needle (Maxiprobe, Dentsply Tulsa Dental, Tulsa, OK, USA). The final irrigation regimen consisted of 10ml NaOCl 3%, followed by 10ml EDTA 17% and 10ml NaOCl 3%. The instrumented root canals were dried with paper points.

Obturation

Prior to obturation, roots were randomly assigned into 3 groups, each containing 12 root canals. In all roots, small amounts of sealer AH 26, (Dentsply, DeTrey, Konstanz, Germany) were applied with a no 25 K file in a counter-clockwise rotation. In case a root contained two separate canals, one was always obturated using the lateral compaction technique.

Group A: Lateral compaction. A no 35/.02 gutta-percha cone was used as master cone. A finger spreader 20/.04 was gently used and no 20 gutta-percha were used as accessory cones. When no more accessory cones could be introduced in the canal, gutta-percha excess was cut with System B and the filling materials were vertically compacted.

Group B: System B (SuperEndo-α2 (alpha2), B&L Biotech, Ansan, South Korea). A Fine Medium gutta-percha cone was fitted to tug back. The appropriate System B plugger was inserted 4 to 6 mm from working length to cut gutta-percha and then it was vertically compacted. The backfill was performed with Obtura (SuperEndo-β (beta) – B&L Biotech, Ansan, South Korea) in two steps.

Group C: Thermafil (Dentsply, Tulsa Dental Specialties, Tulsa, OK). Obturation with Thermafil was performed according to manufacturers' instructions. Since the appropriate verifier was used at working length, the selected obturator was placed in the Thermaprep and the heater was activated. When it was ready, the obturator was immediately inserted into the canal to the working length using a firm and steady pressure. The handle was removed after gutta-percha was set with a cone bur.

For each of the 30 roots, after root canal obturation, radiographs were taken to evaluate their quality. Samples were incubated in 37^{o} C and 100% humidity for two weeks.

Sample observation under Stereomicroscope

On the surface of each root, the levels of sections were noted. Then, they were embedded in transparent acrylic resin. After the set of blocks, they were sectioned with the aid of a microtome (IsoMet 4000 Precision Cutter, Buehler, Lake Bluff, IL, USA) perpendicular to their vertical root axis at each section point, with a diamond disk under water cooling, at 0 mm, 3 mm and 5 mm from working length.

The coronal side of sections was photographed at x6 magnification using stereomicroscope (Leica, Wetzlar, Germany). These digital images were interpreted in the program Image J software (National Institute of Health, public domain). and the area of root canal was illustrated. When isthmuses were evident, they were excluded from the measurement. The total area of the canal was identified as CANAL AREA. Also, the total area of voids was recorded as VOIDS (Figure 1a). All measurements were made at scale of μm^2. The percentage of voids occupied in the canal was estimated. Each measurement was carried twice at different times.

In addition, when an isthmus was present at any section level, it was recorded. The maximum penetration depth of the filling materials into the isthmus was measured in μm (Figure 1b).

Statistical analysis

SPSS 19.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. The tests used were One-Way ANOVA, Kruskal Wallis and Wilcoxon test. The level of significance was set at $p<0.05$. One-Way ANOVA was used when regularity and homoscedasticity of populations were applied. When they were not, Kruskal Wallis was chosen. Also, for the comparison of the two measurements Wilcoxon test was applied, the rest performed with their means. Shapiro-Wilk test was used to test normality and Leven test to test homoscedasticity.

RESULTS AND DISCUSSION

No procedural errors during the chemomechanical procedure were performed using BioRaCe.

Two of the 90 sections were destroyed during the sectioning procedure (one of group A, and one of group B). No significant difference was recorded between two independent measurements (p>0,05). Also, no statistically significant difference was recorded for working length among three groups. On the other hand, Schneider´s angle was statistically significant different for the groups (p = 0.015). However, Spearman rank correlation proved that correlation between angle of curvature and total area of voids (or their percentage) is very low (p>0.05).

In 60 sections, no voids could be recorded, 20 per group. At 0 section level, there were less sections without voids (12) compared to the other levels (24 each).

No section level had statistically significant difference for neither the total area of voids nor the corresponding percentages for any of the examined techniques (Table 1). Also, the difference for each group was not statistically significant (p=0.496). Contrary, there was statistically significant difference for the section levels. In section level 0 bigger voids were recorded compared to section level 5 (p(voids)=0.003, p(percentage)=0.001). Between section levels 0 and 3 mm or 3 and 5 mm, the difference was not statistically significant.

Table 1: Total area of voids (TAV) and their corresponding percentage % (P) in the root canal (Mean, SD) for each section level and obturation group

Section Level	Group	TAV (μm^2) Mean	SD	P (%) Mean	SD
0 mm	A	23283.746	40687.680	7.100	12.090
	B	23527.280	45144.415	9.622	15.048
	C	44335.000	61527.506	21.323	27.546
3 mm	A	7686.846	16629.422	2.612	7.014
	B	15547.336	35141.095	3.890	7.363
	C	4235.708	10402.830	1.407	3.523
5 mm	A	9602.441	27367.478	0.381	0.835
	B	2151.537	3771.125	0.407	0.723
	C	1147.675	3193.686	0.182	0.491

Isthmuses were observed in 47 photographs. Only section levels 3 and 5 mm were included due to the absence of isthmuses at 0-section level. Group B demonstrated maximum penetration depth at 5 section level (Table 2). In addition, Group B exhibited higher penetration depth in comparison with Group A, regardless of section level (p=0.012). Finally, at 5 section level, the filling materials penetrated deeper into the isthmus (p=0.027).

Table 2: Maximum Penetration (MP) depth of root canal filling materials in isthmuses (Mean, SD) for each group, at each section level.

Section Level	Group	MP Mean	SD
3 mm	A	93.667	125.618
	B	257.833	362.126
	C	428.333	350.466

5 mm	A	243.167	280.618
	B	1448.429	858.637
	C	577.556	432.641

The group of lateral compaction demonstrated the greatest heterogeneity, especially in oval-shaped canal sections. Voids were present between gutta-percha cones or between gutta-percha and canal walls. The group of System B/ Obtura had the most homogenous cross-sections. In addition, formation of mixture of sealer and gutta-percha was noticed. In the group of Thermafil, total or partial denudation of the carrier was noticed. In the majority of cross-sections (31/36) the carrier was eccentrically placed inside the root canal (Figure 2).

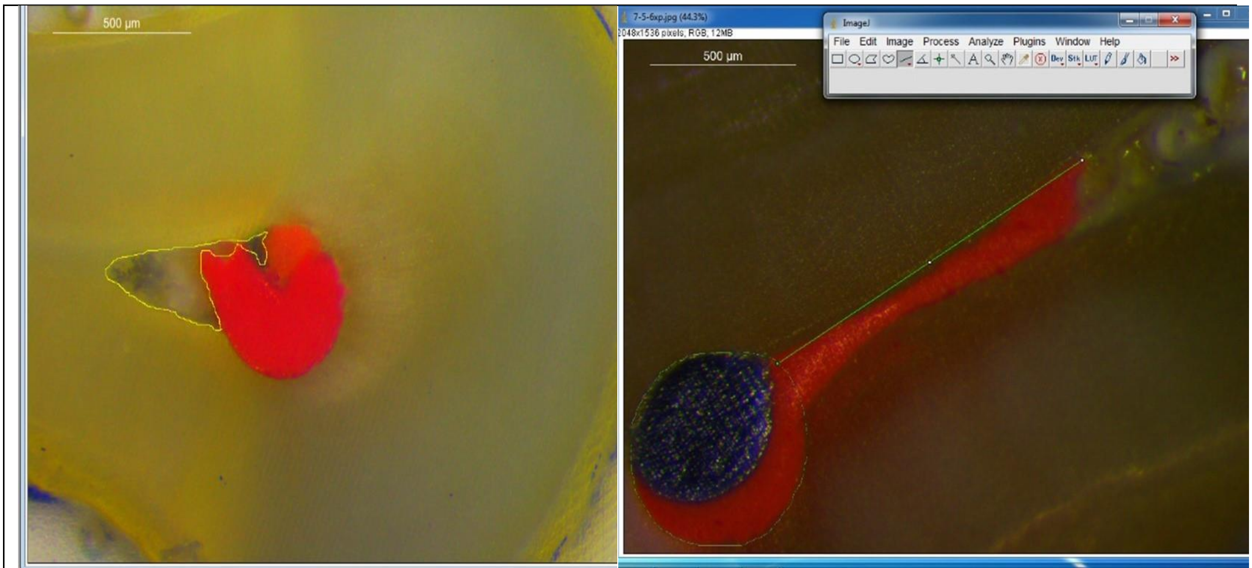

Figure 1. Program Image J was used for measurements. 1.a Total area of voids 1.b. Maximum penetration depth in isthmus.

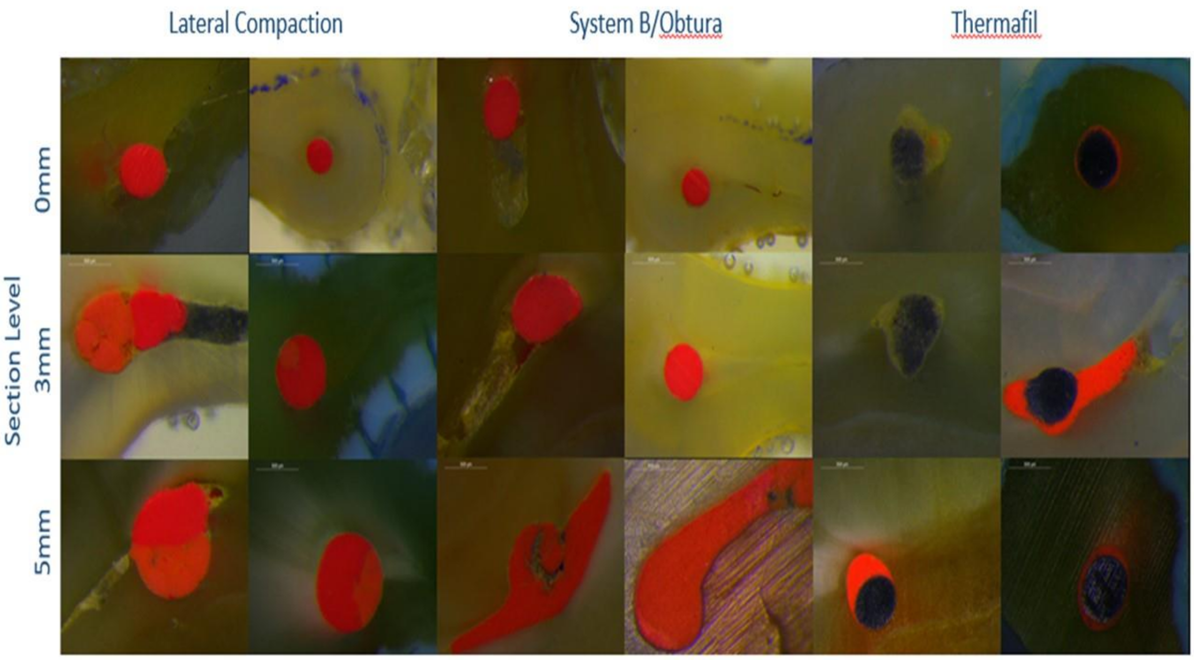

Figure 2: In the left column of each obturation technique are depicted the worst images at each section level, whereas on the right the best images are shown.

In lateral compaction heterogeneity is illustrated. System B/ Obtura group provided homogenous sealing in most sections. In Thermafil group, partial or entire denudation of the core can be observed.

DISCUSSION

Several studies have applied similar methodology, for microvoids determination, to this study. However, sample of previous studies consisted of straight canals; severely curved root canals in natural teeth were included for the first time (9,10). Only two studies have been performed in curved canals but both used resin blocks (11,12). So, their anatomy has little resemblance to the complicated anatomy of a natural tooth, particularly to a molar. In 2007 Dedeus et al. (13) used mesial roots of lower molars, without mentioning details concerning their curvature, to compare the percentage of root filling material using SEM. Their results favoured Thermafil, a finding that disagrees with the current study, though a tendency for sections of 3mm and 5mm was also recorded. The percentages of voids in both studies are similar for the corresponding sections (0.41±0.09% to 3.82±1.92% for Dedeus (13) and 0.18±0.49% to 3.9±7.4% in this study). Iglecias et al. (14) also used mesial roots of mandibular molars, though Schneider's angle was between 25^{o} and 35^{o}, in our study only roots above 35^{o} were included. They used a non-destructive method, micro-CT to quantify voids; differences between obturation techniques (single cone, continuous wave condensation) were recorded only in the cervical third.

In this study no difference was found among the different obturation techniques used i.e. lateral compaction, system B and Thermafil. This comes to agreement with other studies, even though the methodology was not identical (15-18). Also, it was recorded that the more apical the sections studied, the more voids were detected, in agreement with Gordon et al. 2005 (12). On the contrary to Celikten et al. (18) study, where fewer voids are observed in the apical region compared to the coronal third. On the other hand, there are many studies that found differences among the tested techniques either in general or in a specific section. The main reason for this disagreement is considered the use of straight root canals or resin blocks instead of naturally curved teeth (9-12, 19-21).

Few studies have dealt with the size of microvoids remaining after root canal obturation. In 2005 ElAyouti et al. (22) used molars, premolars and incisors to evaluate obturation of Guttaflow, System B/Obtura and lateral compaction using stereomicroscope. They calculated the area of independent voids in each section, whereas in this study the total area of voids was estimated, so it is impossible for direct correlations to be performed. Although the mean void size in ElAyouti et al. (22) study was 30μm^2, in this study through the processing with Image J, the minimum area of independent voids that could be recorded was 75μm^2. In 2006 Epley et al. (23) used straight root canals to compare obturation materials (Resilon and gutta-percha) and techniques (lateral compaction, System B/Obtura). Their results concerning the size of microvoids in sections of 3 and 5 mm agree with the present study. In working length section Epley et al (23) report voids 1337.8-5501.6μm^2, while here the respective estimation was 23283.7- 44335μm^2. This difference is obviously explained by the parameter of curvature.

Analyzing the results, it was observed that the mean was smaller than standard deviation. This problem was also observed in other similar studies (16,17,24). First of all, this finding could be attributed to the small sample size. Also, all the measurements were performed in μm; it is possible that a change to mm^2 would lead in a smaller standard deviation (10). Finally, the smallest size of voids was 75 μm^2 and the total area of voids 215μm^2. Smaller voids could not be recorded and measured, presumably they were not included as voids, leading to many zero calculations and resulting in high standard deviation. Finally, the choice of calculation of total area of voids instead of area of root filling material, which is used in the majority of similar studies, had its limitations, considering the many 0 findings and the minimum measurement.

Isthmus obturation has very few references in the literature. In 2011, Endal et al. (8) used microcomputed tomography for this purpose. They noted insertion of filling materials in isthmuses but they occupied less space proportional to the main canal. This is a result of dentin chips accumulation in this particular area hindering the penetration of gutta-percha and sealer.

In this study the obturation quality of isthmuses was off-topic, the maximum penetration depth was recorded and which technique could obtain it. Warm techniques (System B, Thermafil) proved to be more efficient compared to cold lateral compaction. Also, penetration depth was statistically higher in the 5mm section. This difference was attributed to the observation of isthmuses having less debris and being wider in 5mm than in 3mm.

The present study was performed under ex vivo conditions which do not directly apply to the common clinical practice. Under the limitations of this study, it can be concluded that lateral compaction, System B and Thermafil provide similar obturation quality in severely curved root canals. Maximum penetration of obturation materials in isthmuses is provided by System B. The heterogeneity among observational methodologies in calculating the remaining voids makes the comparisons among studies difficult and their results incomparable. It is a strong need for criteria for observational studies to be formed and applied (25).

HIGHLIGHTS

All the examined obturation methods produced similar obturation quality in severely curved root canals. More voids are observed in the more apical sections of the root canal irrespectively to obturation method. Obturation with System B/ Obtura results in deeper penetration of the gutta-percha n isthmus.

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