Assessment of apical microleakage using tooth clearing method between two softened core obturation techniques

Nadia S. Wongsari,* Christine A. Rovani, Aries C. Trilaksana

Abstract

Objective: This study aimed to compare apical microleakage using tooth clearing method between two softened core obturation techniques: carrier-based gutta-percha and continuous wave.

Material and Methods: The samples were maxillary first incisors with a single root canal. They were divided into three groups of 9 each randomly. The first group was carrier-based gutta-percha, the second group was continuous wave and the third group was lateral condensation as positive control. The teeth were decoronated at the cemento-enamel junction (CEJ), prepared with crown down pressureless technique and obturated according to their group. All the samples were coated with nail polish except for 2 mm from the apical,

and then placed in China Ink for 7 days. Data were collected and analyzed using Anova and Tukey's post hoc test.

Results: The study showed there were 3 (33.3%) of 9 samples in the category score of 1 and there were 6 (66.7%) of 9 samples that were included in the category score of 2. This group has the most member group with a score of 2 among the groups and that mean of apical microleakage from continuous wave technique was (0.256+0.133) in which it was lower than carrier-based gutta-percha (0.433+0.173).

Conclusion: There is a significant difference of apical microleakage between continuous wave and carrier-based gutta-percha.

Keywords: Apical microleakage, Softened core, Carrier-based gutta-percha, Continuous wave, Tooth clearing

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Introduction

The success of root canal treatment depends on the opening of the access, cleaning and shaping quality and hermetic root canal obturation. Obturation aims to fill the entire root canal system from the corona to the apical direction by creating a seal so that the possibility of reinfection can be prevented.¹⁻³ The better the seal, the better the teeth prognosis.⁴

Apical region is a complex area and becomes the driveway of bacteria and their toxins. A common cause of root canal treatment failure is the lack of quality leading to the apical microleakage.⁵ Microleakage seal is the access of tissue fluids, micro-organisms and their toxins into the root canal and cause failure of the root canal treatment.^{6,7}

Apical microleakage formed between filler and canal walls will affect the treatment results.^{8,9} Therefore, many obturation techniques have been developed to increase treatment success recently.

Based on the treatment of fillers, obturation techniques are mainly divided into two core techniques, namely solid core and soft core techniques.¹⁰ Gutta-percha lateral condensation core applies a solid core techniques and it is recently still a main option.^{11,12} This technique is taught in most dentistry field and is still the standard obturation. The advantage of

this technique is its ability to control the placement of gutta-percha. However, final product obturation does not form a homogeneous mass just a collection of gutta-percha fused because of the sealer. Moreover, it can leave the space between the gutta-percha and the canal walls as a result of imperfect preparation techniques, curved root canal or even inadequately lateral condensation obturation techniques.^{4,11,13}

Carrier-based gutta-percha and continuous wave is just one example of softened core obturation techniques.¹⁰ Carrier-based gutta-percha is relatively easy and quick technique.^{14,15} Principle of this technique is the use of a carrier coated with gutta-percha and then heated. Because of the properties of gutta-percha which becomes plastic when heated, the gutta-percha can easily fill into lateral root canal and the additional root canal.^{15,16} The disadvantage of this technique is the possibility of gutta-percha to be detached from its carrier.^{16,17}

Continuous wave obturation technique is considered to be capable of filling the root canal and increase the density of gutta-percha, which is theoretically capable of creating a good apical seal, thereby reducing the risk of apical microleakage. However there is a risk of extrusion of the filler materials.^{13,18}

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Excipients that is commonly used is a combination of sealer and gutta-percha, which is recently still the standard.^{2,19} The sealer is expected to bind gutta-percha to the canal walls, gutta-percha and fill the area that cannot be filled by gutta-percha. Sealer based on mineral trioxide aggregate (MTA) has a better degree of adhesion than conventional zinc oxide-eugenol sealer and has a level which is equivalent to the resin-based sealer. In addition, the MTA sealer is biocompatible and capable of stimulating mineralization.²⁰ Microleakage test which is also most widely used is the ink penetration model because it is relatively easy to conduct.^{1,11} The principle of this test is a capillary phenomenon where the teeth is soaked in ink so the ink penetrates into the room formed between a root canal and filler.¹ Tooth clearing material is one method to observe the ink penetration.^{21,22} For the last few decades, tooth clearing had been used to study the morphology of human dental pulp. In addition, this method is also used in research of apical microleakage to observe the penetration of ink. This method includes three stages which consists of demineralization, dehydration and clearing.¹¹

In this study, we compared the apical microleakage using clearing tooth method of two softened core obturation techniques: carrier-based gutta-percha and continuous-wave.

Material and Methods

Samples that met the inclusion criteria were decoronated in CEJ. The samples were divided into 3 groups with a sample size of 9 teeth sample of each group. The first group is obturated with carrier-based gutta-percha technique, the second group was obturated with continuous wave technique, and third group was obturated with lateral condensation technique, as a positive control.

The preparation of the root canal was applied using rotary instruments (X-smart, Dentsply, Switzerland) to F5. Each file was re-irrigated with NaOCl 2.5% and applied with lubricant Glyde. At the end of the preparation, irrigation of 17% EDTA, 2.5% NaOCl and distilled water was also applied. Root canals were dried with paper points and obturated according to the sample group using gutta-percha and MTA-based sealer (Fillapex, Angelus, Brazil). After doing obturation, roentgen picture was performed and root canals were covered with glass ionomer cement (GIC) and composites. The sample was then put into an incubator at a temperature of 37°C for 3 × 24 hours.

Samples on the root part were covered with 2 layers of nail polish, except for 2 mm of the root tip. The samples were then immersed in Indian ink

for 7 × 24 hours, removed, rinsed with water and the nail polish was removed using acetone and dried for 1 × 24 hours. The following step was clearing tooth procedure which included demineralization where the samples were stored in 10% nitric acid for 3 × 24 hours. Samples were then rinsed with flowing water for 1 minute dehydration was carried out by immersing the samples in sequence of 70% alcohol, 90% alcohol and 100% alcohol for 20 minutes. Then, samples were dried and cleared with tissue paper and then immersed in methyl salicylate until they became transparent.

Penetration dye was evaluated from apical end to the corona with a light microscope. Score 0 meant the penetration of ink 0 mm, a score of 1 meant that the penetration of ink <0.5 mm, a score of 2 meant that the ink penetration of 0.5–1 mm, score of 3 meant that the ink penetration 1–2 mm and a score of 4 meant the penetration of ink >2 mm.²³

Results

Table 1 shows that in the lateral condensation group, there were 3 (33.3%) of 9 samples in the category score of 1 and there were 6 (66.7%) of 9 samples that were included in the category score of 2. This group has the most member group with a score of 2 among the groups. In the obturated group with carrier based gutta-percha revealed more than 50% of the sample had a score of 1, further there were 5 of 9 samples (55.6%) that were included in the category score of 1. The remaining 4 samples (44.4%) were included in the category score of 2. Furthermore, the results of research on groups of continuous wave technique shows that over 80% of the samples included in the category score of 1, i.e., 8 out of 9 samples. This was the group getting scored 1 among other groups. Only 11.1% of the samples fell within a score of 2.

Table 2 shows the difference in the apical microleakage distance between obturated techniques such as carrier-based gutta-percha, continuous wave and lateral condensation. The results showed ink penetration was the highest in the control group or the lateral condensation technique with a mean value of 0.544 mm. The lowest ink penetration found in the group obturated with continuous wave technique, which was an average of 0.256 mm. Groups of samples obturated with carrier based gutta-percha technique have an average penetration of ink as far as 0.433 mm.

One-way Anova test results show the value of $p=0.003$. It shows that there are significant differences in the dimensions of apical microleakage between carrier-based gutta-percha obturation techniques, continuous wave, and lateral condensation ($p<0.05$).

Table 1 Distribution of penetration by apical microleakage categories according to the type of obturation techniques

Type Obturation Techniques	Observations Category Apical Microleakage					Total
	Score 0	Score 1	Score 2	Score 3	Score 4	
	n (%)	n (%)	n (%)	n (%)	n (%)	
Lateral condensation (control)	0 (0%)	3 (33.3%)	6 (66.7%)	0 (0%)	0 (0%)	9 (33.3%)
Carrier-based gutta-percha	0 (0%)	5 (55.6%)	4 (44.4%)	0 (0%)	0 (0%)	9 (33.3%)
Continuous wave	0 (0%)	8 (88.9%)	1 (11.1%)	0 (0%)	0 (0%)	9 (33.3%)
Total	0 (0%)	16 (59.3%)	11 (40.7%)	0 (0%)	0 (0%)	27 (100%)

Table 2 The difference between the apical microleakage of carrier-based gutta-percha, continuous wave and lateral condensation obturation technique

Obturation Techniques	n (%)	Apical Microleakage (mm)	p-Value
		Mean±SD	
Lateral Condensation (control)	9 (33.3)	0.544±0.167*	0.003**
Carrier based gutta-percha	9 (33.3)	0.433±0.173*	
Continuous wave	9 (33.3)	0.256±0.133	
Total	27 (100)	0.411±0.194	

*Shapiro–Wilk test $p>0.05$ Normal data distribution

**one-way Anova: $p<0.05$ significant

Table 3 Further results of different test of apical microleakage between carrier-based gutta-percha, continuous wave and lateral condensation obturation techniques (control)

Obturation Techniques (i)	Standard (j)	Mean Difference (i–j)	95% CI (min–max)	p-Value
Lateral Condensation	Carrier based	0.1111	-0.076–0.298	0.316
	Continuous wave	0.2889	0.102–0.476	0.002*
Carrier based	Continuous wave	0.1778	0.009–0.365	0.034*

*post hoc Tukey's: highly significant difference (HSD): $p<0.05$ significant

Table 3 shows the results of different post-test apical microleakage between carrier-based obturation techniques gutta-percha, continuous wave and the lateral condensation technique as a control.

Different test results further demonstrate the dimensions of apical microleakage in carrier-based gutta-percha group at any time is always higher than the continuous wave group. This is supported by the results of statistical tests that shows the value of $p=0.034$, which means that there is a significant difference of apical microleakage between the dimensions carrier-based gutta-percha technique with continuous wave technique ($p<0.05$).

Discussion

Topics of apical microleakage are still interesting to be discussed, because even if it is accompanied by technological developments in the field of root canal treatment, clinical failure can still occur. One of the causes of the failure of root canal treatment is non-hermetic obturation.^{24,25}

Some of the materials and techniques have been developed to improve the quality of root canal obturation. Pashley mentions that the apical microleakage is fairly severe clinical problem because each ingredient and obturation techniques have different levels of apical microleakage.^{25,26} This research was conducted to evaluate the apical microleakage using tooth clearing between two types of softened core obturation techniques which are continuous wave and carrier-based gutta-percha.

Coloring agent penetration test was used to assess the apical microleakage. The coloring agent used in this study was China ink. Sample was soaked in the ink so that the ink could penetrate into the apical microleakage formed between the canal walls and the filler materials.^{1,22,24}

In this research, methods like tooth clearing were applied to see the penetration of ink. The advantages of tooth clearing covers: A. To maintain the original shape, B. To shows the overall morphology of the root canal, C. Relatively inexpensive, D. Samples can be stored for a long time and e. is easy

to conduct. This method includes three phases, namely demineralization, dehydration and clearing.^{24,27}

After the sample passed through the clearing stages of tooth, the penetration of ink could be seen using a microscope at 40x magnification (10x ocular and 4x objective lens).

The use of condensing type lateral obturation techniques was used as a positive control because recently lateral condensation technique is still applicable to most clinicians and is still taught in the schools of dentistry. However, according to Eguchi et al, the lateral condensation technique using excessive sealer can lead to leakage, which lowers the quality of the root canal obturation.²⁸ In addition, the obturation does not result in a homogeneous mass and it is difficult to fill the lateral root canal.^{12,29}

Obturation of softened core techniques includes carrier-based gutta-percha and continuous wave techniques are developed to solve the problems caused by solid core obturation techniques. Based on table 1, it can be seen that the distribution of the observations from the category penetration (apical microleakage) by type of obturation techniques (carrier-based gutta-percha, continuous wave, as well as lateral condensation). All samples have apical microleakage.

Table 2 shows the difference between the apical microleakage obturation among the carrier-based gutta-percha technique, continuous wave and lateral condensation significantly. Continuous wave technique has the lowest average apical microleakage, followed by carrier-based gutta-percha techniques and lateral condensation technique as the highest.

The apical microleakage at several different obturation techniques. The apical micro-leakage occurs in all obturation techniques. The finding of this research provides insights that apical microleakage is influenced by many parameters like anatomy and clinical considerations, such as the root morphology, anatomical shape of the root canal and the ability of the operator, as well as the obturation technique.^{4,10}

Table 3 shows the results of different post-test apical microleakage between carrier-based obturation techniques gutta-percha, continuous wave and the lateral condensation technique. The test results showed that the apical microleakage in lateral condensation technique is greater than the carrier-based gutta-percha ($p=0.316$), but it does not reveal a significant difference. They reveal the effect of the curvature of the root of the carrier-based gutta-percha technique and found

that there is no significant difference of apical microleakage between lateral condensation of gutta-percha and a carrier-based at the root of the curvature of less than 25°. However, significant results are found at the root of the curvature more than 25°. This is due to the assumption that lateral condensation cannot afford the obturation well due to the curvature of the root.³⁰

There is no significant difference of apical microleakage between lateral condensation technique and carrier-based gutta-percha when sealer is used. It shows that the use of sealer role during the transformation from α -phase to β -phase which can cause shrinkage of gutta-percha. The sealer is expected to compensate for the lack of gutta-percha.³⁰

Caravanshad and torabinejad compare carrier based gutta-percha and lateral condensation. They found that apical microleakage on a carrier based gutta-percha is greater than the lateral condensation. The differences in results can be caused by different sealer used. They use a sealer made from ZnO-eugenol, where as this study were using MTA-based sealer. As known, a MTA based sealer has an excellent level of adhesion to dentin.^{31,32}

Apical microleakage in continuous wave technique is smaller than the lateral condensation ($p<0.002$). These results show a significant difference ($p<0.05$) in line with Silva et al which examined the ability of lateral condensation technique and continuous wave in lateral root canal filling. They found that the technique of continuous wave is better than lateral condensation technique. Continuous wave technique is capable of filling up to the lateral root canals so that the apical microleakage can be minimized.³³

The apical microleakage occurring between the lateral condensation technique and continuous wave. They found that continuous wave technique has smaller microleakage than that of lateral condensation. In their study, they assume that the root canal with good cleaning and shaping will facilitate the gutta-percha to flow along the root canal.¹¹

Whereas, lateral condensation occurs apical microleakage less than that of continuous wave. This difference may be due to the smear layer which is not removed that affects the penetration of ink. While in this study, the smear layer is removed by irrigation with 17% EDTA and NaOCl 2.5%.^{11,34}

Furthermore, for the two softened core obturation techniques, the carrier-based gutta-percha and continuous wave, a significant difference ($p=0.034$) was found. Apical

microleakage in continuous wave is smaller than those of the carrier based gutta-percha. This may be caused by gutta-percha on continuous wave technique that experienced a gradual shrinkage according to the principle of continuous wave compared to the techniques of carrier based gutta-percha in the form of the mass of gutta-percha.²⁸

In addition, the technique of continuous wave are accompanied by vertical condensation.^{10,31} The thermomechanical properties of gutta-percha, and stated that the vertical pressure should be given in all softened core obturation techniques to compensate for changes in volume of gutta-percha along with cooling process.^{25,35}

The results of this study are not consistent with the Roots and Tamer, stating that the apical microleakage in continuous wave is larger than that of carrier-based gutta-percha. This difference may be attributed to differences in the depth of the heat plugger applications. This is supported by Silva et al.³³ stating these differences can be attributed to differences in the depth of the plugger application of heat, which can affect the adaptation of gutta-percha. Apply heat in 3, 5 and 7 mm from the apical end and expressed increasingly that the deeper the plugger enter, the better the adaptation of gutta-percha.³¹

Conclusion

From this study assessing the apical microleakage using tooth clearance techniques of softened core between the carrier-based gutta-percha techniques and continuous wave techniques, it is concluded that the apical microleakage continuous wave technique is smaller compared to the carrier-based gutta-percha technique.

It is advised to assess the apical microleakage between carrier-based gutta-percha and continuous wave techniques using different test methods. In addition, it requires follow-up with different ink soaking time to observe the apical microleakage at each obturation techniques.

Conflict of Interest

The authors report no conflict of interest.

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