Original Article

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Comparison of Microleakage between Resin-based and Bioceramic-based Root Canal Sealers by Fluid Filtration Technique.

Paveepong Tanompetsanga and Pakit Tungsawat

D.D.S., Dip. Thai Board of Endodontics. College of Dental Medicine, Rangsit University

Objectives: The aim of this study was to compare the microleakage between resin-based (AH Plus®) and bioceramic-based (EndoSequence BC Sealer®) root canal sealers using the fluid filtration technique.

Materials and methods: Seventy extracted human mandibular premolars resected 12 mm from the apex were instrumented to size 50/.04 using the Mtwo rotary system. They were then randomly divided into three experimental groups based on obturation technique and sealer (G1: AH Plus obturated by warm vertical compaction, G2: EndoSequence BC Sealer obturated by sealer-based technique, and G3: EndoSequence BC Sealer obturated by warm vertical compaction), and two control groups. After their completed obturations, the samples were stored in containers of 100 percent relative humidity for seven days. Microleakage was assessed using fluid filtration method, employing a pressure equivalent to 30 cmH_2O through a 1-mm diameter capillary tube. Statistical analysis was performed using the one-way ANOVA test followed by Dunnett T3 for multiple comparison tests at the 0.05 significance level.

Results: The leakage rate of EndoSequence BC Sealer by sealer-based technique group were statistically significantly higher than EndoSequence BC Sealer by warm vertical compaction group ($p = 0.013$). However, no significant difference was found between the AH Plus group and both the EndoSequence BC Sealer groups ($p > 0.05$).

Keywords: bioceramic, calcium silicate, fluid filtration, microleakage, root canal obturation

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Introduction

A complete three-dimensional filling of the entire root canal space is one of the key components for a successful root canal treatment. [1-4] Gutta-percha and root canal sealer are materials regularly used to seal off the root canal system. However, there are several different types of root canal sealers currently available in the market. Zinc-oxide-based and resin-based sealers are quite popular and have been used for many years. However, these two sealers have certain disadvantages, including dissolution in fluids and shrinkage after setting. [5, 6] This resulted in the development of new root canal sealers including the bioceramic sealer to overcome these disadvantages. Bioceramic utilizes moisture to initiate its setting reaction, has a slight setting expansion and a high pH level. [7] This allows bioceramic to flow and adapt well to the root canal walls [8-10] and accounts for several of the listed criteria of an ideal root canal filling material as presented by Grossman. [11] Moreover, as bioceramic is bioactive, it can stimulate the production of bone and cementum. [12-14]

Correspondence author: Pakit Tungsawat
College of Dental Medicine, Rangsit University
52/347 Muang-Ake Phaholyothin Road Lak-Hok Muang Pathum Thani 12000, Thailand
Tel: 0-2997-2200 to 4319 Fax: 0-2997-2200 to 4321 E-mail: pakit.tu@rsu.ac.th
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AH Plus (DENTSPLY DeTrey) is a second generation epoxy resin sealer that modified formulation of AH-26 in which formaldehyde is not released. [15] The sealing abilities of AH-26 and AH Plus appear comparable. [16] AH Plus is an epoxy resin-amine based system that comes in two tubes. The epoxide paste tube contains a diepoxide (bisphenol-A diglycidyl ether) and fillers as the major ingredients, while the amine paste tube contains a primary monoamine, a secondary diamine, a disecondary diamine, silicone oil, and fillers as the major ingredients. It exhibits a working time of approximately 4 hours. AH Plus presents low solubility and disintegration, adequate radiopacity [17, 18], high bonding strength to root dentin [19], adequate expansion [18], antimicrobial activity, and other desirable biological properties. [20, 21]

EndoSequence BC Sealer is a pre-mixed bioceramic sealer with calcium silicate powder as its main component. The manufacturers recommend its obturation by single cone technique. However, this term of the root canal obturation technique may be confused with the traditional single cone technique. Trope has recently proposed a more appropriate term, namely sealer-based technique. To validate and substantiate the manufacturer recommendations, a microleakage study should be conducted to compare its sealing ability with sealers that are commonly used nowadays. Zhang et al. had studied the difference in fluid leakage between the root canal that was obturated with iRoot SP and AH Plus using a Protaper gutta-percha Point (Dentsply Maillefer). [22] Gutta-percha impregnated with bioceramic particle is gutta-percha point, which is impregnated on the surface with a nanoparticle layer of bioceramic. [23] Its surface bonding to the sealer eliminates a critical pathway for coronal leakage of microbes if the coronal restoration has a defective seal. The gutta-percha also is used as a pathway for post preparation or retreatment if necessary. Additional the gutta-percha is used primarily as the delivery device (plugger) to allow hydraulic movement of the sealer into the irregularities of the root canal and accessory canals. A recent study using bacterial leakage to evaluate sealing ability of root canal obturated with bioceramic-impregnated gutta-percha cone and non-modified gutta-percha, with bioceramic sealer or AH Plus found that no significant differences in bacterial leakage among the groups. However, the matched single cone technique was merely an obturation technique in that study. [24] Therefore, the goal of this study was to compare the apical microleakage of the root canals obturated with AH Plus by warm vertical compaction and EndoSequence BC sealer both by sealer-based technique and warm vertical compaction technique.

Materials and methods

Sample

Seventy human mandibular premolars extracted for orthodontic purposes were immediately soaked in 0.1% thymol solution prior to the beginning of the experiment.

The premolars were resected 12 mm from their apexes and the patency of each root canal was confirmed by insertion of a #10 K-file through the apical foramen. Real canal length was determined by manually inserting a #10 K-file into the canal until the instrument tip was visible at the apical foramen. Working length was established at 1.0 mm short of the real root canal length. All samples had a similar canal size at the apex, where #10 or #15 K-file demonstrated fit at the apical part of the canal. All roots were radiographed from both buccolingual and mesiodistal directions to determine the width of the canals at apical one-third. The difference of the canal width must lesser than 1.0 mm. If any tooth did not fit the aforementioned criteria, it was excluded. All root canals were shaped using Mtwo rotary files to size 50/.04 and irrigated with 5 ml of 2.5% sodium hypochlorite solution at each file change. After complete root canal shaping, each root canal was flushed with 2 ml of a 17% EDTA solution for 1 minute, 10 ml of a 2.5% sodium hypochlorite, then dried with five pieces of paper points.

The samples were divided into 3 experimental groups; 20 roots per group, as well as a positive and negative control groups; 5 roots per group.

Group 1: AH Plus sealer by a warm vertical compaction technique (n=20)

Twenty roots were filled using a greater taper gutta-percha cone size 50/.04 (EndoSequence® Gutta Percha Points, Brasseler USA) with AH Plus sealer and the Beefill system (VDW® GmbH, München, Germany). The gutta-percha cone was coated with AH Plus at its apical third and fitted to the working length. Gutta-percha was cut at the coronal end and lightly compacted with the endodontic plugger with a 1.0 mm diameter at working end. The Beefill heat carrier size 60/.06 and endodontic plugger with a 0.6 mm diameter working end was used to down-pack the gutta-percha to 4 mm short of the working length in manner of continuous wave technique. Then backfill continued with alternations between injecting warm gutta-percha and condensation with the endodontic plugger until complete.

Group 2: EndoSequence BC Sealer by a sealer-based technique (n=20)

Twenty roots were filled with EndoSequence BC Sealer and gutta-percha impregnated with bioceramic particles (EndoSequence® BC Points™, Brasseler USA) by a sealer-based technique. The EndoSequence BC Sealer syringe tip was inserted within the coronal third of the root canal. A small amount of EndoSequence BC Sealer was gently and smoothly dispensed into the root canal by compressing the plunger of the syringe for one volume calibration mark. Using a #15 K-file, the canal walls were lightly coated with the existing sealer in the canal. Subsequently, the master gutta-percha cone was coated with a thin layer of sealer and slowly inserted into the canal to deliver sufficient sealer to the apex. Using a heat source, the gutta-percha cone was cut at the coronal end of the root and vertically condensed. The excess sealer was removed with a moist cotton pellet.

Group 3: EndoSequence BC Sealer by a warm vertical compaction technique (n=20)

The procedure was performed in the same manner as in group 1 with using EndoSequence BC Sealer and gutta-percha impregnated with bioceramic particles

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Positive control group (n=5)

Five roots were prepared using Mtwo rotary files to size 50/.04 and irrigated with 5 ml of 2.5% sodium hypochlorite solution at each file change. After complete root canal shaping, each root canal was flushed with 2 ml of a 17% EDTA solution for 1 minute, 10 ml of a 2.5% sodium hypochlorite, then dried with five pieces of paper points. The canals were filled with a greater taper gutta-percha cone size 50/.04 without the use of a sealer.

Negative control group (n=5)

Five roots were prepared in the same manner as the positive control group. Then the roots were completely covered with two layers of nail varnish, including the coronal end and apical foramen, to gain a hermetic seal.

After the root canals were completely sealed, they were kept in a container of 100% relative humidity at room temperature for seven days until microleakage evaluation.

Evaluation of microleakage

The method described by Wu and Wesselink was used for the measurement of microleakage. [25] The external root surfaces of all specimens were coated with nail varnish except for an area of 1 mm coronal and apical end of the root. The specimens were then connected to the fluid filtration device (figure 1). The connection was sealed with cyanoacrylate glue and multiple layers of silicone sealant (Neobond®) to obtain a closed system. Leakage was evaluated by the fluid filtration method employing a pressure equivalent to 30 cmH_20. [26] The passage of liquid through the samples was assessed by measurement of bubble displacement. A 16-megapixel digital camera (Olympus OM-D-E-M10) and ImageJ program version 1.51j8 were used to record and analyze the bubble movement. Measurements of bubble movement were made at 15-minute intervals for 3 hours. Any possible leakage in the system was tested by using tissue paper wrap around the connecting joint between the sample and the device. If the tissue paper got wet its indicate the leakage of the system; the sample was reattached to the device. The data were begin recording when the tissue paper had dried for 30 minutes, and the tissue paper must dry throughout the leakage test.

$$V = \frac{\pi r^2 l}{p \cdot t}$$

The acquired values were then averaged. ImageJ program version 1.51j8 (National Institute of Health, USA) was used to measure bubble displacement of each sample in millimeters and calculate the liquid leakage rate using the following formula.

v = inflitration rate ($nL/cmH_2O \cdot min$)
l = length of air bubble movement (mm)
r = internal diameter of micropipette (mm)
p = pressure (cmH_2O)
t = time (min)

Five roots of positive control and negative control groups were tested before evaluating the microleakage of the experimental groups.

Statistical Analysis

The data were analyzed using SPSS 24.0 for Windows (SPSS Inc, Chicago, IL). The average and standard deviation of the liquid leakage rate for each group were calculated. The data analysis would be performed by One-way ANOVA and multiple comparisons by Dunnett T3 test. All statistical analyses were set at a significance level of 0.05.

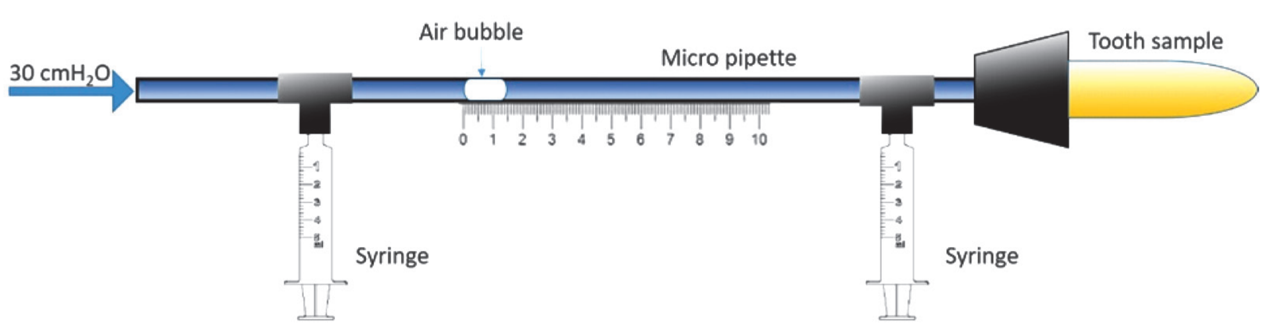

Figure 1 Fluid filtration device for leakage determination.

Results

The data for apical leakage of each group were shown in Table 1. The leakage of the negative controls, as measured by the fluid filtration model, were uniformly 0, and the leakage of the positive controls could not be record because the bubble had moved through the capillary of the fluid filtration device for less than 15 minutes.

According to statistical analysis, the microleakage rate of each group was a normal distribution, but the homogeneity of variance did not achieve. Therefore, One-way ANOVA was used to compare the means of microleakage rate between three group and multiple comparisons were performed by Dunnett T3. group 1: AH Plus sealer by warm vertical compaction had a leakage rate not different from group 2: EndoSequence BC Sealer by sealer-based technique ($p = 0.10$) and group 3: EndoSequence BC Sealer by warm vertical compaction ($p = 0.11$). However, the leakage rate of group 2 was statistically significantly higher than group 3 ($p = 0.013$).

Discussion

EndoSequence BC Sealer is a bioceramic sealer with calcium silicate as its main component. [27] It has several unique properties which makes it preferable to other sealers. It can set in a humid atmosphere, a slight setting expansion, and a high pH level during its setting reaction. [28, 29] According to manufacturer recommendation, EndoSequence BC Sealer a suitable material for root canal obturation by single cone technique, where the gutta-percha cone delivers the sealer into the canal and serves as a central guide for filling removal in retreatment cases. [30, 31] This study compared the microleakage of root canals filled with gutta-percha and AH Plus sealer by warm vertical compaction technique, gutta-percha impregnated with bioceramic particles and EndoSequence BC Sealer by sealer-based technique, and gutta-percha impregnated with bioceramic particles and EndoSequence BC Sealer by sealer-based technique warm vertical compaction technique to provide further information to aid in the selection of obturation materials and techniques.

In this study found that Group 2 had the highest leakage rate, followed by Group 1 and Group 3, respectively. This result corresponded with Zhang et al. which compared the rate of fluid leakage between iRoot SP (bioceramic-based sealer) and AH Plus. [22] They found that obturation with iRoot SP by single cone technique had the highest leakage rate, followed by AH Plus by warm vertical compaction and iRoot SP by warm vertical compaction technique, respectively.

Table 1 Microleakage rate when root canals were obturated with gutta-percha with AH Plus sealer and EndoSequence BC Sealer

Group	mean ± SD ($nL/cmH_2O \cdot min$)
1. AH Plus with warm vertical compaction technique	$3.1 \pm 1.3^{a, b}$
2. EndoSequence BC Sealer with sealer-based technique	5.1 ± 3.7^{a}
3. EndoSequence BC Sealer with warm vertical compaction technique	2.4 ± 0.9^{b}

*Values with the same superscript are not statistically different ($p > 0.05$).

In this study also found a statistically significant difference between the EndoSequence BC Sealer group by sealer-based technique and the EndoSequence BC Sealer group by warm vertical compaction technique. This result was different from the previous study which did not find any significant difference in leakage between their three groups. [22] The difference may result from the different fluid filtration pressures selected for each study. Our study applied a pressure of 30 cmH_2O which is equal to 0.03 atm, whereas Zhang et al. applied pressure of 0.2 atm. The higher pressure may cause the increased fluid filtration rate of each group, thereby leading to the increased standard deviation of their study. [26]

The EndoSequence BC Sealer group obturated by warm vertical compaction had less leakage than the group obturated by sealer-based technique. Superior sealing ability of warm vertical compaction could due to vertical compaction technique pushes gutta-percha and sealer providing for greater penetration to every part of the canal. The sealer-based technique relies on hydraulic pressure from the gutta-percha cone to lead and spread the sealer throughout the canal. [32]

The heat produced from warm vertical compaction can negatively affect the moisture present within the root canal. In the previous study found that a high temperature significantly reduces the setting time and the flow of bioceramic-based sealer. [33] Therefore, EndoSequence BC Sealer properties could have been affected leading to a decrease in the sealing ability. However, it has been found that heating and plugging gutta-percha increases apical sealing ability significantly, by increasing adaptation to the root canal walls, apical adjustment of gutta-percha, and the propulsion of sealers into lateral or accessory canals. [32] Nevertheless, in this study, the sealing abilities of AH Plus and EndoSequence BC Sealer were not found to be significantly different.

This study used gutta-percha impregnated and coated with bioceramic nanoparticles as the EndoSequence BC Sealer manufacturers claim that bonding between EndoSequence BC Sealer and the gutta-percha surface will reduce potential leakage. However, our study found no significant leakage difference between the AH Plus group and EndoSequence BC Sealer groups. This is in agreement with the previous study that used plain gutta-percha, uncoated by bioceramic nanoparticles. [22]

According to our data, with regards to fluid leakage, root canal obturation with gutta-percha impregnated with bioceramic particles and EndoSequence BC Sealer by warm vertical compaction can substitute obturation with AH Plus sealer by warm vertical compaction. If EndoSequence BC sealer is selected, Warm vertical compaction will provide greater seal than sealer-based technique. Furthermore, the additional benefits associated with the properties of bioceramic sealers is a slight setting expansion, high setting pH level, ability to set in a humid atmosphere and less stress applied to the tooth during obturation. [34] Nevertheless, clinical studies in this area are required to evaluate its clinical performance.

Conclusion

Root canal obturation with gutta-percha impregnated with bioceramic particles and EndoSequence BC Sealer by sealer-based technique has a higher leakage than obturation with gutta-percha impregnated with bioceramic particles and EndoSequence BC Sealer by warm vertical technique. However, the leakage rate of both EndoSequence BC Sealer group not different from obturation with gutta-percha and AH Plus by warm vertical compaction.

Conflicts of interest

The authors have no conflicts of interest relevant to this article.

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