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Research Article

COMPARISON OF THREE BIOCERAMIC SEALERS IN TERMS OF DENTINAL SEALING ABILITY IN THE ROOT CANAL

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ABSTRACT

Objective: The main objective of endodontic treatment is to prevent further infection or reinfection by eliminating microorganisms within the root canal system. Proper endodontic treatment could prevent apical and coronal penetration of fluids and microorganisms. Endodontic sealer is vital components of root canal obturation to establish a fluid-tight seal. Bioceramic-based root canal sealers are considered to be an advantageous technology in endodontics and have been found to be both biocompatible and comparable to other commercial sealers. The aim of this study was to compare the adhesion of three bioceramic sealers within the root canal system.

Methods: Endodontically treated teeth were obturated using three types of bioceramic sealers and then divided into three groups. Specimens were then observed using a scanning electron microscope, and the attachment distance was measured using ImageJ.

Results: The three groups exhibited were statistically significant differences ($p<0.05$) in dentinal sealing ability. Calcium phosphate silicate-based sealer showed the highest sealing ability, followed by pure tricalcium silicate-based bioceramic sealers and then tricalcium silicate and resin-based bioceramic sealers.

Conclusion: The sealing ability of calcium phosphate silicate-based sealer is superior to that of both pure tricalcium silicate-based and tricalcium silicate- and resin-based sealer.

Keywords: Bioceramics, Dentinal sealing ability, Sealers, Sealing ability, Dentinal tubules, Scanning electron microscope.

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INTRODUCTION

Root canal treatment performed to eliminate microorganisms and prevent reinfection. After cleaning and shaping, an effective root canal filling is necessary to maintain microorganism-free environment within the root canal and avoid recontamination [1-3]. The sealing ability, biocompatibility, and antimicrobial properties of root canal filling materials are important factors in accomplishing this task. Sealers that could adapt closely to the dentinal canal walls aimed at preventing leakage in the apical region [3-5]. As incomplete sealing of the root canals will lead to major endodontic failure, it is essential to use materials that can form a hermetic seal within the root canal system. Filling materials that evoke a biological response at the material dentin interface represent an improvement in the quality of sealing [6-9].

Bioactive endodontic sealers have been developed to improve the quality of root canal obturation. There are now three types of bioceramic sealers with different base materials. These sealers are calcium phosphate silicate-based bioceramic sealers (BioRoot RCS; Septodont, Saint-Maur-Des-Fosses, France), tricalcium silicate- and resin-based bioceramic sealers (MTA Fillapex; Angelus Industry Dental Products S/A, Londrina, PR, Brazil), and pure tricalcium silicate-based bioceramic sealers (iRoot; Innovative BioCeramix, Vancouver, BC, Canada) [10,11].

The components of bioceramic sealers are zirconium oxide, calcium silicates, calcium phosphate monobasic, calcium, hydroxide, fillers, and thickening agents. Contemporary studies on bioceramic-based sealer have found adequate characteristics, including its adhesive property [5-11].

The bioactive property of the sealer for obturation material, specifically certain compositions of glasses comprising SiO_2, CaO, Na_2O, and P_2O_5, can bond to either the dentinal or root tissue. In general, when the bioactive sealer comes into contact with the root canal, it may induce a phosphate buffered solution, forming a tag-like structure, and it may form a fluid-tight seal with the root canal. Bioceramic materials contain calcium phosphate, which enhances the setting properties of bioceramics and creates a chemical composition and crystalline structure similar to those of tooth and bone apatite materials [12-14], thus improving sealer-to-root dentin bonding.

This *in vitro* study was performed to assess and compare the apical sealing ability of three bioceramic-based sealers: Calcium phosphate silicate-based bioceramic sealers (BioRoot), tricalcium silicate- and resin-based bioceramic sealers (MTAF), and pure tricalcium silicate-based bioceramic sealers (iRoot), which are considered to be the gold standard of sealing and adhesion to dentin [15-17].

The aim of this study was to compare three bioceramic sealers in terms of sealer adhesion in the root canal. The bioceramic sealer may have similar dentinal sealing ability within the root canal, and better sealing ability could be obtained from the tested sealers.

METHODS

In this study, we used 27 single-rooted, human mandibular premolars that were cleaned with a scaler and soaked with 0.9% NaCl solution. The experiment was performed under ethical clearance protocol number 051111018 from Universitas Indonesia Ethics and Research Department. Three team members who had been calibrated performed the experiments. Specimens were examined under an operating microscope (Carl Zeiss Meditec AG, Germany) at ×20, and we excluded teeth that were either fractured or cracked and had calcifications, resorbed roots, curved canals, or caries. Radiograph images (Digora, Soredex, Finland) were obtained to confirm the presence of a single unmanipulated canal without resorption and calcification. Specimens were accessed using round diamond burs and then prepared using the crown-down technique. A #10 K-file (Dentsply Maillefer, Switzerland) was inserted into the root canal to the tip of the apex, and then, 0.5 mm was deducted from the apex; this length was determined as the working length. The samples were prepared through the crown-down technique using the Rotary ProTaper Next instrument (Dentsply Maillefer, Switzerland) until ×3 with 0.07 taper.

EDTA gel with 17% concentration was used for preparation. Irrigation was conducted using 2 ml of 2.5% NaOCl and 1 ml 17% EDTA between each instrumentation, and agitation was performed using sonic instruments (Endoactivator, Dentsply, Switzerland). Irrigation was then concluded using 2 ml of distilled water.

Specimens that had been prepared were then obturated with gutta-percha ProTaper Next cone (Dentsply Maillefer, Ballaigues, Switzerland) and bioceramic sealers (iRoot® SP, MTA Fillapex, and BioRoot RCS). Sealers were inserted into the root canal as per the manufacturer's protocols. The coronal area was sealed using resin-modified glass ionomer cement. Specimens then stored in an incubator for 5 days at 37°C and 100% humidity to allow the sealers to set.

The specimens were then mounted in a wax block, and the quality of root canal filling was assessed further using Digital Radiograph Imaging (Digora, Soredex, Finland). Roots were grooved longitudinally and split into two halves by placing a cement spatula in the grooves and applying gentle pressure. We then vacuum dried the sections, coated them with 20 nm gold, and examined them at the apical third of the root canal using a scanning electron microscope (SEM) (Carl Zeiss NTS GmbH, Oberkochen, Germany). We examined the dentinal sealing ability and adaptation of each sealant to the dentin at ×1500 and then took microphotographs. These were then calculated with ImageJ software (LOCI, Wisconsin, USA).

The gap distances between filler material gutta-percha and dentinal tubules were measured by picking spots at random at the apical third of the cross-section. The data obtained were analyzed through parametric statistical tests using SPSS software ver. 22.0. Statistical analysis was conducted after first normality tests data. As the data distribution was normal (parametric), one-way ANOVA statistical test with a significance limit of α=0.05 was performed.

RESULTS AND DISCUSSION

SEM analysis

SEM analyses of the root canals that were obturated using three different sealers showed that their adaptation to dentin was sufficient for good sealing ability along the root canal as seen at Fig 1. The teeth filled with calcium silicate-based sealers exhibited a smooth contact line on the sealer-dentin interface as seen at Fig 2. There was a clear margin between the sealer and the dentinal walls. The teeth filled with gutta-percha exhibited good adhesion to the dentinal walls (Figs 3 and 4), and clear bonding surfaces were observed. Moreover, the textures of the sealers along the root canal were homogenous. The finding was assessed by studying the gap distance between the sealer and the root canal.

Statistic analysis

One-way ANOVA confirmed the existence of significant differences in the dentinal sealing abilities of the three groups. Calcium phosphate silicate-based bioceramic sealers (BioRoot) was significantly has higher sealing ability than tricalcium silicate- and resin-based bioceramic sealers (MTAF) but showed no significant differences with pure tricalcium silicate-based bioceramic sealers (iRoot). The differences between the three groups were assessed using three independent samples through one-way ANOVA with a confidence interval of 95%. SPSS statistical software (ver. 20.0, Chicago, IL) was used for all analyses, and p<0.05 was considered statistically significant. Statistical analysis from Table 1 shows a significance value of p=0.001 (p<0.05), which reveals that there are significant differences in dentinal sealing ability between the three groups. The table also shows that Group 1 has the better sealing ability, followed by Group 3 and, last, Group 2 (Table 1).

Based on the significance value of a *post hoc* test (multicomparison analysis), the results of the homogeneity test were p<0.018, with a significance limit of <0.05. As the data were heterogeneous, the *post hoc.*

Tamhane test was used. The test showed significant differences in the gap distance between the three bioceramic sealer groups, with a significance limit of p=0.001 (p<0.05) (Table 2).

Several studies have demonstrated the presence of microorganisms, including bacteria, in the dentinal tubules and cementum following endodontic treatment [7-9]. A root canal sealer with high antimicrobial activity is an important tool for reducing the growth of microbes and preventing them from reentering the root canal system [10-13].

Bioceramic material is an ideal bioactive sealant, and available bioceramic sealers include three different core materials. These sealers are calcium phosphate silicate-based bioceramic sealers (BioRoot), tricalcium silicate- and resin-based bioceramic sealers (MTAF), and pure tricalcium silicate-based bioceramic sealers (iRoot). This study was conducted to compare the dentinal sealing abilities of these three sealers.

Root canal sealer adhesion defines as the capacity to aggregate the root filling material and maintains the filler as a compact mass along the root canal and provides a single block configuration that seals the canal space hermetically. Tagger *et al.* [18] argued that the term adhesion should be replaced with the term bonding when discussing sealers as the attachment between the substances involves mechanical interlocking forces and not molecular attraction. The potential adhesion of root canal filling materials has been tested commonly from the perspectives of bond strength and microleakage, and there have been no standard methods to measure it.

In a similar study, Zhang *et al.* (2009) examined the sealing abilities of bioceramic sealers and pure resin-based sealers. They found that both sealers produced gap-free and gap-containing regions within the root canals. In this study, we found SEM observation showed that the apical third adaptation of both bioceramic sealers is quite the same [9,10]. Another study demonstrated that removal of the smear layer had no

Table 1: The mean value and standard deviation of the dentinal sealing abilities of three different sealers

Sealer	n	Mean (SD)	p value
Group 1	9	3.90 (2.46)	0.01
Group 2	9	42.24 (9.54)	
Group 3	9	4.99 (2.17)	

Group 1 – calcium phosphate silicate-based bioceramic sealers (BioRoot), Group 2 – tricalcium silicate- and resin-based bioceramic sealers (MTA Fillapex), Group 3 – pure tricalcium silicate-based bioceramic sealers (iRoot)

Table 2: The significance values of the dentinal sealing ability of three different sealers

Sealer type	Group 1	Group 2	Group 3
Group 1		0.001*	0.708
Group 2			0.001*

Post hoc Tamhane test, p<0.05

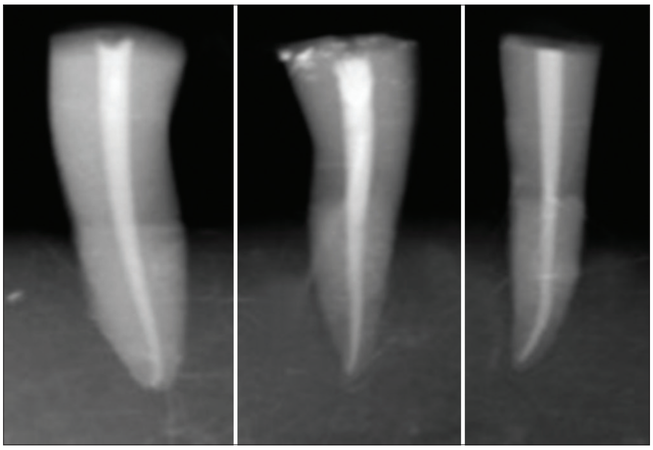

Fig. 1: Digital radiograph evaluation of obturation. A. Group 1: Calcium phosphate silicate-based bioceramic sealer. B, Group 2: Tricalcium silicate- and resin-based bioceramic sealer. C. Group 3: Pure tricalcium silicate-based bioceramic sealer

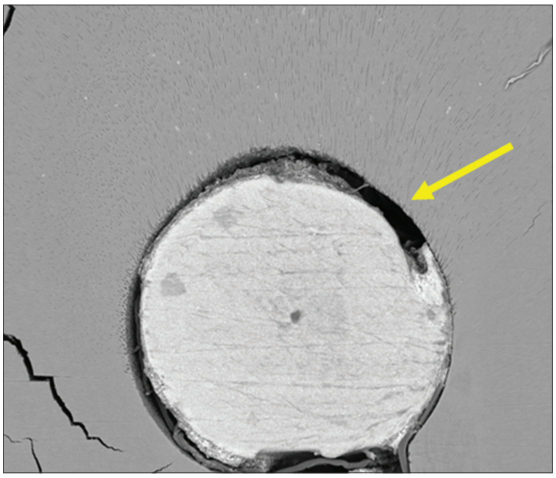

Fig. 2: Samples of Group 2 shows a mild gap between the sealer and the root canal

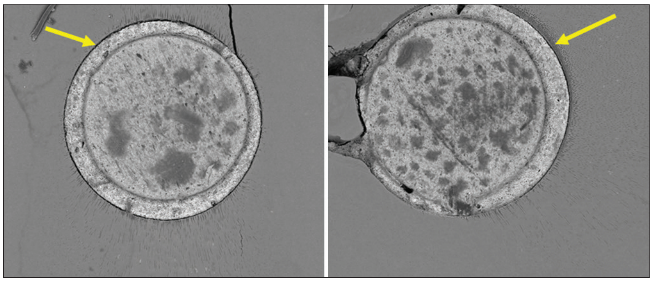

Fig. 3: Samples of Group 1 show the capability of the sealer to create intact seals of the root canal

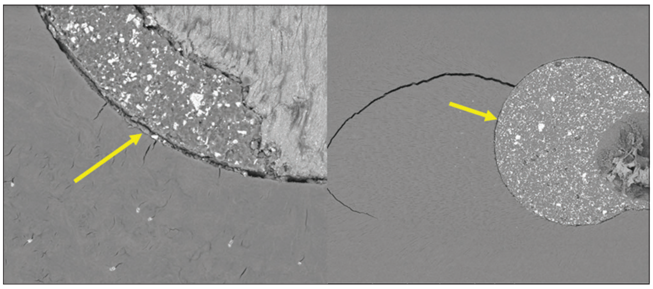

Fig. 4: Samples of Group 3 show some mild gaps in a couple of the dentinal walls and intact sealing ability for the rest of the canals

direct effect on the sealing ability of pure tricalcium silicate-based sealer, but the sealing ability with resin addition was less than was that of pure tricalcium silicate [18,19]. The radiopacity (equal to 7.06 mm of aluminum) and flow of bioceramic sealers were higher than were those of resin added sealers.

Solubility is related to the sealing ability of a sealer, as it must be bonded tightly to dentin and to root canal filling cones [4,7,15,16]. Several studies have assessed the sealing abilities of different bioceramic-based sealers in vitro. Further, various methodologies have revealed that the sealing ability of bioceramic-based sealers is satisfactory and comparable to that of other commercially available sealers. We used the same methodology to compare three different sealers to determine their relative performances to achieve a better prognosis in treating patients [17,20, 21-23].

The morphology of the root canal may influence the quality of obturation. We used mandibular premolars with single and straight canals to simplify the preparation process and facilitate operation of the microscope. Irrigation solutions of 2 ml each of 2.5% NaOCl and 17% EDTA were applied to clean the root canal effectively, remove the smear layer, and open the dentinal tubules. EDTA also has low surface tension and could increase the porosity in root canal treatment, removing smear layers in particular, which could enhance the sealants' access and adaptation to the dentin.

Our laboratory experiment compared the dentinal sealing ability of three different bioceramic sealers. Federer's formula was used to obtain a total sample of 27 teeth, divided into three groups with nine teeth in each group. We measured and calculated the gap between gutta-percha and the pulpodentinal junction [13,24-26].

In this study, the teeth were cut with diamond disc until the cement-enamel junction was reached to obtain a uniform working length of 15 mm. Root canal preparation was performed using rotary instruments because that is the most common approach currently, and it simplifies the preparation process and provides a more uniform preparation.

SEM assesses the dentinal sealing ability and adhesiveness of the sealer to dentin walls at various levels of sectioning. In this study, SEM showed that specimens obturated with BioRoot and iRoot had good adhesion to the dentinal walls and to the gutta-percha core. As expected, there were differences in the adhesive properties of endodontic sealers because of their chemical and physical composition [18,19,27-29].

Testing the sealing ability at the root canal revealed no significant differences between calcium phosphate silicate-based bioceramic sealers and pure tricalcium silicate-based bioceramic sealers; however, it revealed significant differences with tricalcium silicate- and resin-based bioceramic sealers. The tricalcium silicate structure has substantial granule, it would give adequate sealing ability in dentinal tubules, despite being lower than the other bioceramic-based sealers.

Within the limitations of this study, BioRoot and iRoot bioceramic sealers, along with gutta-percha, outperformed the gold standard, and the performance of MTAF was not up to par. However, further clinical studies are necessary to determine the long-term results with these materials, as it is better to have no gap at all, given that bacteria can be smaller than 4 microns.

CONCLUSION

Our findings indicated that bioceramic-based root canal sealers yield promising results and that calcium phosphate silicate-based bioceramic sealers (BioRoot) have better sealing ability than do pure tricalcium silicate-based bioceramic sealers and tricalcium silicate- and resin-based bioceramic sealers. Difference in the sealing ability of calcium phosphate silicate-based bioceramic sealers and pure tricalcium silicate-based bioceramic sealers was statistically insignificant, showing that the two groups have equal capacity.

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