Comparison sealability of root canal obturation using bioceramic sealer and methacrylate resin-based sealer

Y Muharsya, M Usman and E Suprastiwi*

Department of Conservative Dentistry, Faculty of Dentistry, Universitas Indonesia, Jakarta, Indonesia
*E-mail: esuprastiwi@yahoo.co.id

Abstract. This study aimed to compare and analyze the obturation sealability using bioceramic sealer and methacrylate resin-based sealer. A total of 30 single-rooted teeth were prepared using ProTaper Next and randomly divided into two groups; the first group was obturated with bioceramic sealer (SB), while the second was obturated with methacrylate resin-based sealer (MRS). Coated gutta-percha was used as obturating material in both groups. Apical third marginal adaptation was evaluated by observing the dye penetration between the obturation material and the root canal walls on cross-sectioned samples. BS showed less microleakage in the apical third marginal adaptation than MRS. Obturation of root canal using BS has better sealing ability than MRS at the apical third.

1. Introduction

The main purpose of root canal treatment is to reduce the number of microbial entities and to prevent future re-infection. In order to do so, adequate closure of the root canal is required to ensure that the bacteria will not proliferate to cause a pathological condition. Two primary materials are used to fill the root canal: gutta-percha, as the main material, and root canal sealer. Gutta-percha is a biocompatible obturating material and can be used to fill the radicular space. However, the use of gutta-percha alone is not sufficient to create three-dimensional closure, as it cannot be attached to the canal wall; therefore, the use of sealer, which helps create adhesion between gutta-percha and canal walls, is required [1]. Root canal sealer material acts to fill minor irregularities and discrepancies between the gutta-percha and the canal walls [1]. It also serves as a lubricant and can fill accessory canals, meaning that the use of a root canal sealer and gutta-percha plays an important role in creating a fluid, tight, and sealed closure. The ideal root canal sealers are expected to create a bond between the main material (gutta-percha) and dentin in the root canal to prevent leakage. They should also be non-toxic and have a healing effect on periapical lesions [2].

Epoxy resin sealer has good physical properties, good apical closure, and an adequate biological performance. However, the closure of the canal in three dimensions cannot be achieved in the absence of chemical bonds between the polyisoprene of the gutta-percha cone and components of the sealer; there would be no strengthening of the root structure and microleakage could result [2]. In current resin sealer development, the aim is to improve its physical properties, in order to achieve objectives that are in accordance with the concept of a monoblock. Monoblock is a condition in which the root canal space is completely filled, leaving no gap, by a solid mass composed of different materials and surfaces. This can increase the density and resistance to root fracture, and is also expected to close the bacterial entrance to the root canal system, which exists in the form of a gap due to a leak. A monoblock-bond

can be formed of sealer and gutta-percha to obtain a strong bond between the primary filler material and the root canal walls and to create a good closure [2,3].

A methacrylate resin-based sealer (MRS), which has hydrophilic properties and an effective dentin tubule flow capacity, thus having good closing ability, has been developed [4].The use of an MRS is combined with resin-coated gutta-percha. The goal is to produce charging in accordance with the concept of a tertiary monoblock, which is a filling with two bonds – one between the sealer and the root canal and one between the sealer and the resin-coated gutta-percha. Root canal obturation using MRS and resin-coated gutta-percha cones is an implementation of this concept [4,5]. A new sealer has been developed based on a bioceramic with better properties than resin sealer; it does not shrink when hardened and is not toxic to fibroblasts [6,7]. The use of this sealer can be combined with gutta-percha that is coated with bioceramic nanoparticles, so it is expected that a tertiary monoblock can be achieved. Few previous studies have examined the use of bioceramic sealer (BS), so further research of its closure capability is required [6].

2. Materials and Methods

The method used was immersion of the teeth in Indian ink. The immersing method is a passive technique with which to observe and evaluate the leakage of root canal filling, and it relies on capillary fluid movement. Indian ink penetrates the apex along the gap that exists between the canal wall and root canal filling, after which the teeth are cut in a cross-sectional direction to enable the assessment of color penetration [8]. In order to assess whether there is marginal leakage from the root canal filling, a cross-section cutting method is used, and the teeth are then given one of five ratings; a score of 0 (no slit edge), a score of 1 (there is a marginal gap on one quadrant), a score of 2 (there is a marginal gap on the second quadrant), a score of 3 (there is a marginal gap on the third quadrant), and a score of 4 (there is a marginal gap on the entire quadrant or an absence of adaptation) [9].

All specimens were cleaned with scaler and then soaked in saline solution prior to preparation and obturation of the root canal. The specimens were extracted teeth with a root canal, and a round diamond bur was used until straight access to the root canal was obtained. All coronal parts were cut, leaving the roots. The samples were then randomized and divided into two groups: an BS group and an MRS group. The crown down preparation technique, employing the ProTaper NEXT rotary instrument, was used for both groups. The working length was determined as ± 1 mm of the apical foramen. EDTA gel (17%) was used as a lubricant when preparing the root canals, when changing instruments, and when irrigating with 1 ml NaOCl (2.5%) in each instrument replacement. After completion of root canal preparation, all root canals were irrigated with 17% EDTA solution, then rinsed again with 2.5% NaOCl and dried with paper points.

The prepared root canals were irrigated and dried with paper points, after which iRoot SP and EndoREZ sealer was injected into the root canal. The main gutta-percha cone was then smeared with sealer and inserted in the root canal at the working length. Excessive sealer was cleaned, and the gutta-percha cone was cut using a hot instrument. The coronal part was covered with resin-modified glass ionomer cement (RMGIC). Once obturation was complete, the density of the results of all samples was evaluated using radiographs. The coronal parts were given an RMGIC base. The apical parts of each sample were placed on a damp sponge and then incubated for 24 hours at 37 °C with a humidity of 100% to allow the sealer to harden. Each sample was then dried with an air blow, after which the outer surface of the root was coated with two layers of nail polish, except at 1 mm from the apex tip. The first layer was applied and left to dry at 37 °C for 1 hour; the second layer was then applied and left to dry in the same manner. After 1 hour, all samples were immersed in Indian ink at 37 °C for 7 x 24 hours. After the samples were removed from the ink solution, they were washed under running water and then the cross-section cutting process was carried out using a disc with a bucco-lingual direction at 2 mm and 4 mm from the apex [10].

The observation procedure was conducted using a stereo microscope with a magnification of x50. In the present study, the adaptation of the edge of the apical third was determined by examining whether there was a marginal gap between the coated gutta-percha and the sealer and between the sealer and the

dentin after root canal obturation procedures. This was measured via an assessment of dye penetration between the sealer-dentin walls and the sealer-gutta-percha in the samples cut cross-sectionally at 2 mm and 4 mm from the apex. Based on research by Oliveira *et al*. (2013), there were five scores: a score of 0 (no marginal gap), a score of 1 (there was a marginal gap in one quadrant), a score of 2 (there were marginal gaps in two quadrants), a score of 3 (there were marginal gaps in three quadrants) and a score of 4 (there were marginal gaps in all quadrants or an absence of adaptation) [8,11]. The data relating to penetration of dye into the root canal were analyzed via parametric statistical tests using Statistical Package for the Social Sciences software, version 21. A parametric chi-square test was used to examine differences in significance in all groups, with significance being set at $p = 0.05$.

The tooth samples used in the present study were those with a single root canal that had been extracted to facilitate the testing because they had roots that were relatively straight (a degree of curvature of <10° based on the Schneider angle). In addition, the teeth had not undergone root canal treatment and were already fully grown. The exclusion criteria were the presence of caries, a resorption defect, cracks or fractures of the roots, an initial file of more than # 15, and a calcified root canal. Before treatment, the teeth were soaked in a solution of NaCl to retain moisture and to condition the teeth in biologically similar conditions to those of the mouth. A total of 30 teeth were used, with 15 teeth per group, based on G-power calculations. Working length was determined as 1 mm from the apex foramen, using a K-file # 10, which aimed to create an apical stop. An apical stop is a barrier at the end of the preparation, and has two functions, namely to keep the instrument, filling materials, and chemicals in the root canal and not to pass through it, and to create or maintain a barrier to compact gutta-percha [12]. Root canal preparation was carried out using a non-ISO M-Wire-based rotary instrument, ProTaper NEXT, with crown down preparation techniques. The irrigation materials used were NaOCl 2.5%, followed by 17% EDTA for 1 minute, and then a rinse with 2.5% NaOCl [13].

3. Results and Discussion

3.1 Results

A multi table Chi-square test was used to categorically compare two unpaired groups, with signi-ficance being set at $p = 0.05$. The marginal adaptation score of the apical third can be seen in Figure 1, and the distribution of marginal gap scores in the MRS group and the BS group is shown in Table 1.

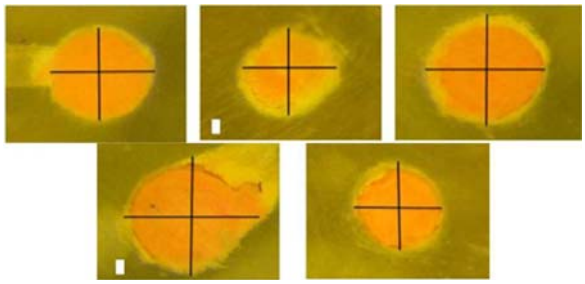

Figure 1. Representative samples showing the marginal adaptation scoresat the apical third based on quadrant distribution. (A) Score 0; (B) Score 1; (C) Score 2; (D) Score 4; (E) Score 5

The chi-square analysis showed that there were significant differences in sealing ability between the BS group and the MRS group. In the BS group, 38 samples (63.3%) had no marginal gaps (a score of 0), while 23 samples (38.3%) with no marginal gaps were observed in the MRS group. The MRS group had a greater number of marginal edge scores of 3 and 4, being 12 (20%) and four (6.7%), respectively, while only three samples had a score of 3 and no samples had a score of 4 in the BS group. These results show that the BS group had a better sealing ability than the MRS group, as shown by the lower number of marginal gaps in the BS group.

Table 1. Distribution of marginal edge scores in the bioceramic sealer and methacrylate resin sealer groups

Sealer	Score									
	0		1		2		3		4	
	n	%	n	%	n	%	n	%	n	%
BS	38	63.3	12	20.0	7	11.7	3	5	0	0.0
MRS	23	38.3	11	18.3	10	16.7	12	20.0	4	6.7

BS = Bioceramicsealer; MRS = Methacrylate resin sealer; 0 = No marginal gap; 1 = Marginal gap in one quadrant; 2 = Marginal gap in two quadrants; 3 = Marginal gap in three quadrants; 4 = Marginal gap in four quadrants

3.2 Discussion

The apical third is the most difficult area to prepare and fill, as it has a complex anatomy, due to many lateral and accessory canals, ramification types, the isthmus, or the apical delta [14]. Tissue fluid from the apex is the biggest cause of root canal treatment failure because it can be a source of nutrients for the bacteria remaining in the root canal. Therefore, the sealing of the root canal, particularly in the apical third, is very important in determining the success of root canal treatment [15]. The present study was conducted to compare the sealing ability of BS and MRS with bioceramic-coated gutta-percha and resin as a tertiary monoblock bond at the apical third. Based on previous studies, the sealing ability of the root filled between the BS and the resin was equivalent to the fluid filtration method [16]. In this current study, the authors further examined the differences in sealing ability between BS and MRS using widely used penetration dyes to observe marginal gaps at the apical third of the apex [17].

The single-cone technique was used for obturation in the present study. This technique uses a single cone of gutta-percha and one type of sealer. A root canal filling system with BS and MRS is designed to use a single-cone technique for using coated gutta-percha with a material that can be fused with a root canal sealer. Tay and Pashley [18], and Zhang *et al.,*[17] stated that the volume of root canal sealers is relatively more than the volume of gutta-percha cone in a single-cone technique, such that the ratio creates the formation of voids (gap) and reduces the quality of the closure. However, the volume of the sealer used in the single-cone technique has been minimized [18,19]. The dye used in the present study was Indian ink. The ink particles had a molecular diameter of 3 μm, and the ink's potential dye penetration ability is different from that of bacterial penetration into the root canal. However, a previous study has suggested that the weight and molecular size of Indian ink is smaller than that of the molecules of bacteria commonly found in the root canal, meaning that it can be used for leak measurement in the apical third of the root canal apex [20].

The results presented in Table 1 showed that there was less marginal leakage in the BS group compared to the MRS group, showing that BS has superior sealing ability to MRS. This contrasts with the results of a study by Zhang *et al.* [17], who used the fluid filtration method and found that the closure ability of resin sealer and BS were equivalent. Pommel *et al*. [21], stated that the weakness of the fluid filtration method lies in the standardization of the materials, and that the methods have not yet been standardized because the variation of pressure ranges between 1–20 Psis, and the timing of the pressure varies between1 minute and 3 hours. Such variations could cause changes in the results obtained. The suitable pressure for fluid filtration techniques such that they mimic the physiological pressure in the oral cavity is 15 Psi, while the pressure used in the study by Zhang *et al.*, was 3 Psi; therefore, this was fairly different from the actual conditions in the mouth [17]. Another variation that could influence the results of studies using these methods is the diameter of the capillary pipes used to produce air bubbles and the diameter of the air bubbles produced [21].

The distribution of the marginal gap scores in the BS and MRS groups showed that there was still microleakage at the apical third, both in obturation with BS and with MRS. These results are consistent with the assertion of Hammad *et al*., that there is no perfect root canal filling and none that has no gaps

[22]. The marginal edge of each specimen might have resulted in working procedure errors. One example of a procedural error of root canal work is excessive dryness when obturating with gutta-percha cones and sealer. The nature of BS and MRS is hydrophilic, so it is best if the second application of the sealer is carried out in a moist root canal [23]. Based on research conducted by Becce [18], obturation of a root canal that is too dry could result in delays in the distribution of sealer to the canal walls, meaning that gap formation occurs. The marginal gaps that occur between coated gutta-percha and sealer could be due to several factors. Hiraishi *et al*. showed that the bond between sealer and coated gutta-percha was not strong because of a lack of free radicals for unification, due to the removal of the oxygen inhibition layer for packing purposes [18].

Another possible cause of the gap between sealer and dentin is due to micro air bubbles at the apical area, which are created by a reaction between NaOCl and organic gas at the root canal. This may mean that the activity of the 17% EDTA irrigation solution becomes ineffective in expelling inorganic substances from the smear layer. The passive irrigation technique, which was carried out with a syringe and an endodontic irrigation needle in the present study, is the simplest technique to use in addressing micro air bubbles that form; agitation irrigation techniques should be used in future studies, as they are more effective in losing smear layer that make better sealer retention with canal walls [24]. As Table 1 shows, statistically significantly more marginal gaps were observed in the MRS group than in the BS group. This is consistent with the previously described theory that the nature of a resin that may contract in volume (shrinkage) can cause voids (gaps) in the root canal filling[4,23].Several morphology and leakage studies showed that the sealing ability of EndoREZ (MRS) was poor, despite the formation of long resin tags in the dentin tubules [18]. According to Bergsman *et al*. (2005), resin sealer may contract due to the polymerization process, resulting in an increase in the distance between the root canal filling (gutta-percha and sealer) and the canal walls [25].

Table 1 also shows that leakage in the apical third still occurred in the BS group, although it was less than that observed in the MRS group. The better sealing ability of the BS group was likely the result of more stable dimensions, due to its composition of inorganic minerals that do not change dimensions when hardened [6]. However, there were still areas with scores of 1, 2, and 3 at 2 mm and 4 mm from the apex in the BS group. This may have been caused by procedural errors, such as dry root canals and irrigation methods that did not use agitation, meaning that the smear layer was not completely lifted [24,25]. Therefore, the results showed that a marginal gap can occur between sealer and dentin and between sealer and coated gutta-percha. The tertiary monoblock that had originally been expected to occur, due to the use of coated gutta-percha, did not form because there remained a marginal gap between the sealer and the gutta-percha. The observation of samples in both sealer groups showed that the majority revealed two attachments in adaptation at the apical third, so the use of the BS and MRS were in accordance with the concept of a secondary monoblock.

4. Conclusion

BS is a better root canal filling sealer than MRS, as shown by the fact that a lower number of marginal gaps were formed at the apical third of the tooth apex in root canal fillings with BS than in those in which MRS was used. It is suggested that future studies use the irrigation technique with agitation, which is more effective in removing the smear layer, in order to obtain improved retention between the sealer and the canal walls. Further studies can be conducted using the same sealer, but with different obturation techniques. Observations in future research can be made using a scanning electron microscope, as it is capable of producing a picture with a high resolution and a maximum magnification to enable viewing of the marginal edge. Decoronation was performed before root canal filling to avoid the formation of a marginal gap between the surface of the root canal walls and the sealers, due to the vibration that results from decoronation, which can then release the sealer from the canal walls. The selection of samples in future studies should use the same teeth elements so that there is uniformity of the cross-sectional shape of the root canal. It is also recommended that a the level of moisture in the root canal is determined at the time of drying, to ensure that the root canal is not too dry, as this can lead to delays in the distribution of sealer and the formation of marginal gaps.

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