Original Article

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Evaluation of the Physical Properties of Different Bioceramic-Based Root Canal Sealers

Farklı Biyoseramik Esaslı Kanal Dolgu Patlarının Fiziksel Özelliklerinin İncelenmesi

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ABSTRACT

Objective: The aim of this study was to evaluate the physicochemical properties of different bioceramic-based root canal sealers.

Methods: Five bioceramic-based sealers; MTA Fillapex, TotalFill BC Sealer, BioRoot RCS, GuttaFlow Bioseal, Dia-Root Bio Sealer were compared with epoxy resin-based sealer (AH Plus) for this purpose. Ten samples of each sealer were prepared in according to the manufacturers' instructions and evaluated for radiopacity, solubility, flow and dimensional change tests. The data were statistically analyzed using One-Way ANOVA and Tukey post-hoc tests ($p<0.05$).

Results: The AH Plus showed statistically higher radioopacity than all tested bioceramic-based sealers ($p<0.01$). A significantly higher solubility rate was observed for TotalFill BC Sealer ($p<0.01$). Dia-Root Bio Sealer, BioRoot RCS and AH Plus showed solubility rate less than 3% in compliance with ISO standards. TotalFill BC Sealer and MTA Fillapex showed higher flow rates than other tested sealers ($p<0.01$). Dia-Root Bio Sealer, GuttaFlow Bioseal, BioRoot RCS, TotalFill BC Sealer and AH Plus exhibited expansion above 0.1%, while MTA Fillapex showed shrinkage less than 1%.

Conclusion: All the tested sealers met the ISO requirements for radioopacity and flow. Among the tested sealers only MTA Fillapex showed dimensional stability consistent with ISO standards. Dia-Root Bio Sealer, BioRoot RCS and AH Plus exhibited solubility rate in compliance with ISO standards. The recently introduced Dia-Root Bio Sealer demonstrated adequate radioopacity, flow and

ÖZ

Amaç: Bu araştırmanın amacı farklı biyoseramik bazlı kanal dolgu patlarının fizikokimyasal özelliklerinin değerlendirilmesidir.

Yöntemler: Bu amaçla beş biyoseramik esaslı kanal patı; MTA Fillapex, TotalFill BC Sealer, BioRoot RCS, GuttaFlow Bioseal, Dia-Root Bio Sealer, epoksi rezin esaslı kanal patı (AH Plus) ile karşılaştırıldı. Üretici firma talimatlarına uygun şekilde her bir kanal patından 10 adet örnek hazırlandı ve radyoopasite, çözünürlük, akıcılık ve boyutsal değişiklik testleri için değerlendirildi. Veriler tek yönlü ANOVA ve Tukey post-hoc testleri kullanılarak istatistiksel olarak analiz edildi ($p<0,05$).

Bulgular: AH Plus, test edilen tüm biyoseramik esaslı kanal patlarından istatiksel olarak daha yüksek radyoopasite göstermiştir ($p<0,01$). TotalFill BC Sealer diğer kanal patlarına göre anlamlı derecede daha fazla çözünürlük göstermiştir ($p<0,01$). Dia-Root Bio Sealer, BioRoot RCS ve AH Plus patları ISO standartlarına uygun olarak %3'ten daha az çözünürlük göstermiştir. TotalFill BC Sealer ve MTA Fillapex diğer kanal patlarından daha yüksek akıcılık göstermiştir ($p<0,01$). MTA Fillapex %1'den az büzülme gösterirken Dia-Root Bio Sealer, GuttaFlow Bioseal, BioRoot RCS, TotalFill BC Sealer ve AH Plus kanal patları %0,1'den fazla ekspansiyon göstermiştir.

Sonuç: Test edilen tüm kanal patları radyoopasite ve akıcılık açısından ISO standartlarını karşılaşmıştır. Test edilen kanal patları arasında sadece MTA Fillapex ISO standartlarına uygun boyutsal stabilite göstermiştir. Dia-Root Bio Sealer, BioRoot RCS ve AH Plus kanal patları ISO standartlarına uygun çözünürlük oranı

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ABSTRACT

solubility, but its dimensional change rate was found to be higher than required by ISO standards.

Keywords: Bioceramics, Dia-Root Bio Sealer, GuttaFlow Bioseal, MTA Fillapex, physical properties, TotalFill BC

ÖZ

göstermiştir. Yakın zamanda piyasaya sürülmüş olan Dia-Root Bio Sealer uygun radyoopasite, akıcılık ve çözünürlük göstermiştir fakat boyutsal değişiklik oranı ISO standartlarından daha yüksek bulunmuştur.

Anahtar Sözcükler: Biyoseramik, Dia-Root Bio Sealer, fiziksel özellikler, GuttaFlow Bioseal, MTA Fillapex, TotalFill BC

Introduction

The primary objective of an ideal root canal treatment is to achieve three-dimensional filling of the root canal system with inert materials. In an ideal root canal obturation, root canal sealers are employed with a semi-solid or solid core material, to create a leak-proof canal seal to establish a strong bond between the core material and the canal wall, effectively filling irregularities such as isthmuses and accessory canals (1).

Ideal root canal sealers should exhibit specific physical and chemical characteristics such as sufficient radioopacity, adequate film thickness, adherence to the root canal wall, dimensional stability and insolubility in tissue fluids beside biocompatibility (2). To assess the quality of root canal sealers, different physical properties must be investigated including flowability, radioopacity, solubility and dimensional stability. Each of these properties plays a crucial role in determining the efficacy and long-term stability of root canal obturation.

Although so many different endodontic sealers have been in endodontic practice for years, none of the available sealers meet all of these requirements, however AH Plus, an epoxy resin-based sealer comes remarkably close and is widely used as the gold standard regarding to its physical characteristics. Nevertheless, critics have pointed out that a significant drawback of AH Plus is its lack of biocompatibility (3). Concerns regarding the cytotoxicity of resin-based sealers lead researchers to focus on developing new sealers which are biocompatible and bioactive. Therefore bioceramic-based root canal sealers were introduced and garnered attention due to their excellent biological properties. The biological properties of these materials namely their biocompatibility and bioactivity, depend on the formation of hydroxyapatite on their surfaces as result of the production of calcium hydroxide ions (4).

In recent years a bioceramic-based root canal sealer, Dia-Root Bio Sealer (Diadent, Republic of Korea) is introduced to the market. Due to its recent introduction, there is no study in literature assessing the physical properties of Dia-Root Bio Sealer. This study aimed to fill that gap in literature by evaluating the physical properties of Dia-Root Bio Sealer, comparing it with other bioceramic-based root canal sealers (MTA Fillapex, TotalFill BC Sealer, BioRoot RCS and GuttaFlow Bioseal) and a resin-based sealer (AH Plus).

The null hypothesis of this study is that Dia-Root Bio Sealer has better physicochemical properties than other bioceramic-based root canal sealers; MTA Fillapex, TotalFill BC Sealer, BioRoot RCS, GuttaFlow Bioseal and resin-based sealer AH Plus in terms of radiopacity, solubility, flowability and dimensional change.

Methods

In this study, the physical properties of five bioceramic-based sealers including MTA Fillapex, Dia-Root Bio Sealer, GuttaFlow Bioseal, BioRoot RCS and TotalFill BC Sealer were compared with the epoxy resin-based sealer AH Plus (Table 1). The sample size for each test was determined with a power test of significance level $\alpha=0.05$ and a power of 80%, requiring at least 4 samples per test. Based on previous studies, a sample size of 10 per group was chosen for a total of 60 samples (6 sealers x10 samples each) to ensure adequate statistical power in comparing the bioceramic-based sealers with AH Plus (5,6).

Radioopacity

Ten samples of each sealer (7.5±0.1 mm diameter, 1±0.1 mm height) were prepared according to the manufacturers' instructions. Once the samples had fully set under conditions of 37 °C and 95% humidity, they were subjected to radiography using a dental X-ray machine. This process was conducted alongside an aluminum step-wedge, incrementally graduated by 1 mm, spanning from 1 mm to 10 mm. The focus-object distance was set to 10 cm and radiographs were taken at 70 kVp, 8 mA and 0.17 seconds. The phosphor storage plates were scanned by Dürr Vistascan digital system (Dürr Dental AG, Bietigheim-Bissingen, Germany). The digital images were exported to ImageJ software (Wayne Rasband, National Institutes of Health, Bethesda, MD, USA). The mean gray value (MGV) was calculated by selecting 3 different areas for each sealer and the aluminum step-wedge. By using regression analysis, a second-degree polynomial was fitted for the gray values of the aluminum steps. The MGV data for each sealer were converted into aluminum step-wedge equivalent thickness (mmAl) with using fitted polynomials.

Solubility

Sample disks (n=10 for each sealer) were prepared using molds (7.5±0.1 mm diameter, 2±0.1 mm height) and set at 37 °C and 95% humidity. After the sealers completely set, they were removed from molds and weighed 3 times using an analytical balance (Ohaus Corp. Pine Brook, NJ USA). The average weights for each sealer were recorded as initial mass (I). Then the samples were placed into 50 mL of distilled water and kept at 37 °C and 95% humidity for 24 h. They were weighed again

3 times and the average weights were recorded as final mass (F). The solubility (S) of each sealer was calculated using the formula S=[(I-F)/I]x100.

Flow

Onto a glass plate, 0.05 mL of freshly mixed material was placed (n=10). After 3 minutes of mixing, another glass plate (20 g) and a 100 g load were placed and kept for 10 minutes on the top of plate. The maximum and the minimum diameter resulting sealer disks were measured using a digital caliper (Mitutoyo Corporation, Japan) with a resolution of 0.01 mm. The mean diameter in mm was recorded as flow rate for each sealer.

Dimensional Change

The cylindrical molds (4 mm diameter, 4 mm height) containing freshly mixed sealers (n=10) were kept at 37 °C and 95% humidity until the specimens were completely set. The flat surfaces of each sample were grinded by a 600-grit wet sandpaper after removing from the mold. The length of each specimen was measured by using a digital caliper (Mitutoyo Corporation, Japan) with resolution 0.01 mm and recorded as initial length (L0). Then the specimens were placed in closed glass flasks containing distilled water and kept in an incubator at 37 °C. The heights of the samples were measured again on the 30th day and recorded as L30. The percentage of dimensional change was calculated with the formula DC=(L30-L0)/L30x100.

Statistical Analysis

Statistical analysis was performed using the SPSS 20.0 program. The data were evaluated statistically using one-way ANOVA and Tukey post-hoc tests at the level of significance ($p<0.05$).

Results

Radioopacity

Table 2 shows the MGV and the equivalent aluminum thickness of the sealers. All the sealers demonstrated radioopacity values above 3 mm of aluminum according to ISO 6876. AH Plus (10.23 mm Al) was found to be statistically the most radioopaque sealer ($p<0.01$). MTA Fillapex was found to be statistically less radioopaque than GuttaFlow Bioseal, TotalFill BC Sealer and AH Plus ($p<0.01$). Statistically no significant difference was found

Table 1. Names, manufacturers and composition of 6 tested sealers

Sealer	Manufacturer	Composition
MTA Fillapex	Angelus, Londrina, PR, Brazil	Base paste: salicylate resin, natural resin, calcium tungstate, nanoparticulated silica, pigments Catalyst paste: diluting resin, MTA, nanoparticulated silica, pigments
Dia-Root Bio Selaer	DiaDent, Heungdeok-gu, Cheongju-si, Chungcheongbuk-do, Republic of Korea	calcium silicate, calcium aluminate, ytterbium trifluoride, zirconium dioxide, silanamine, 1,1,1-trimethyl-n-(trimethylsilyl)-, hydrolysis products with silica, hydroxypropyl methylcellulose, polyethylene glycol 400 and polyethylene glycol 200, polyoxyethylene (20) sorbitan monooleic acid, light mineral oil
GuttaFlow Bioseal	Coltene/Whaledent,Langenau, Switzerland	Gutta-percha powder, polydimethylsiloxane, platinum catalyst, zirconium oxide, silver, coloring, bioactive glass ceramic
BioRoot RCS	Septodont, Saint-Maur-des-Fossés, France	Powder: tricalcium silicate, zirconium oxide, povidone Liquid: aqueous solution of calcium chloride and polycarboxylate
TotalFill BC Sealer	FKG Dentaire, La Chaux-de-Fonds, Switzerland	calcium silicates, calcium phosphate monobasic, zirconium oxide, tantalum oxide and thickening agents
AH Plus	Dentsply DeTrey GmbH, Konstanz, Germany	Bisphenol A/F epoxy resin, calcium tungstate, zirconium oxide, silica, iron oxide pigments, dibenzyldiamine, aminoadamantane, silicone oil

Table 2. Radioopacity, solubility, flow and dimensional change rates of sealers

	MTA Fillapex	Dia-Root Bio Sealer	GuttaFlow Bioseal	BioRoot RCS	TotalFill BC Sealer	AH Plus	p-value
Radioopacity (MGV) and (mmAl) (mean ± standart deviation)	88.11±4.68 3.09±0.07^{c,d}	106±10.9 4.11±0.55^{c,d}	108.22±11.17 4.27±0.91^{c}	96.55±3.97 3.54±0.44^{c,d}	138±5.09 6.47±0.46^{b}	177.33±3.48 10.23±0.26^{a}	<0.01*
Solubility (%) (mean ± standart deviation)	5.57±0.61^{b}	0.06±0.27^{d}	-3.56±0.39^{e}	1.93±0.42^{c}	7.63±0.39^{a}	-0.06±0.03^{d}	<0.01*
Flow (mm) (mean ± standart deviation	28.51±0.95^{a}	25.94±0.75^{b}	22.78±1.22^{c}	26.74±1.87^{b}	29.70±1.01^{a}	23.90±1.67^{c}	<0.01*
Dimensional change (%) (mean ± standart deviation)	-0.60±1.17^{b}	1.53±1.49^{a}	1.96±0.85^{a}	1.74±1.14^{a}	1.72±1.29^{a}	0.57±0.13^{a,b}	<0.01*

*Analysis of variance at the level of significance $p<0.05$. $^{a-e}$: Different letters in the same row indicate significant differences ($p<0.05$).

between radiopacity values of Dia-Root Bio Sealer-GuttaFlow Bioseal (p=0.99), Dia-Root Bio Sealer-BioRoot RCS (p=0.62) and GuttaFlow Bioseal-BioRoot RCS (p=0.42) (Table 3).

Solubility

Table 2 shows the average solubility values (%) for all used sealers. TotalFill BC Sealer (7.63%) was found statistically most soluble than other sealers (p<0.01). No statistically significant difference was found between the solubility rates of Dia-Root Bio Sealer and AH Plus (p=0.98).

GuttaFlow Bioseal (-3.56%) and AH Plus (-0.06%) showed negative solubility and GuttaFlow Bioseal was found less soluble than other sealers (Table 3).

Flow

The mean flow rates of experimented sealers were shown in Table 2. All sealers showed flow rates above 20 mm complying with the ISO requirements. TotalFill BC Sealer (29.7 mm) showed statistically higher flow rate than Dia-Root Bio Sealer, GuttaFlow Bioseal, BioRoot RCS and AH Plus (Table 3), however the difference was not significant between MTA Fillapex (28.51 mm) and TotalFill BC Sealer (p=0.34). Meantime, GuttaFlow Bioseal (22.78 mm) showed statistically lower flow rate than other sealers (p<0.01) but there was no significant difference between AH Plus (23.90 mm) and GuttaFlow Bioseal (p=0.40).

Dimensional Change

Dimensional change rates (%) for each sealer were shown in Table 2. All sealers showed expansion except MTA Fillapex (-0.60 %). GuttaFlow Bioseal (1.96%) exihibited the most expansion rate and AH Plus (0.57%) showed the minimum rate. However, the difference between the expansion rates of the root canal sealers was not statistically significant (Table 3).

Discussion

The radioopacity of root canal sealers is an important property that allows dentists to visualize and assess the quality of a root canal filling on radiograph. It is typically measured in millimeters of aluminum equivalent (mmAl), and higher values indicate greater radiopacity, which makes the material more visible on X-rays. Since the standard of ISO required for minimum radioopacity of root canal sealers was 3 mmAl, all sealers showed adequate radioopacity and met the ISO standards (7). However, it should be noted that the bioceramic-based root canal sealers were found to be less radiopaque than the resin-based sealer AH Plus (10.23 mmAl). The higher radioopacity value of AH Plus might be related to calcium tungstate which was found as an additional radioopacifier beside zirconium oxide. This result was collaborated with previous study results (3,5,6,8-11). TotalFill BC Sealer showed the second highest radioopacity value with 6.47 mmAl. Higher radioopacitiy of TotalFill BC Sealer compared to other bioceramic-based sealers can be explained with its composition. TotalFill BC Sealer contains zirconium oxide and tantalum oxide which are radioopacifiers, whereas BioRoot RCS, GuttaFlow Bioseal and Dia-Root Bio Sealer contain only zirconium oxide (Table 1). The different radioopacifiers may result in different radioopacity values of sealers (10). The radiopacity value of MTA Fillapex (3.09 mmAl) was found to be very close to the minimum threshold specified in ISO standards. In literature the radioopacity value of MTA Fillapex was found to be in range of 2.7 to 8.9 mmAl (12,13). Early versions of MTA Fillapex contained bismuth trioxide, but

Table 3. Comparisons of radioopacity, solubility, flow and dimensional change values among sealers

Sealers	Radioopacity (p value)	Solubility (p value)	Flow (p value)	Dimensional change (p value)
MTA Fillapex-Dia-Root Bio Sealer	0.09	<0.01*	<0.01*	<0.01*
MTA Fillapex-GuttaFlow Bioseal	0.04*	<0.01*	<0.01*	<0.01*
MTA Fillapex-BioRoot RCS	0.72	<0.01*	0.04*	<0.01*
MTA Fillapex-Totalfill BC Sealer	<0.01*	<0.01*	0.34	<0.01*
MTA Fillapex-AH Plus	<0.01*	<0.01*	<0.01*	0.18
Dia-Root Bio Sealer-GuttaFlow Bioseal	0.99	<0.01*	<0.01*	0.95
Dia-Root Bio Sealer- BioRoot RCS	0.62	<0.01*	0.74	0.99
Dia-Root Bio Sealer-TotalFill BC Sealer	<0.01*	<0.01*	<0.01*	0.99
Dia-Root Bio Sealer-AH Plus	<0.01*	0.98	0.01*	0.39
GuttaFlow Bioseal-BioRoot RCS	0.42	<0.01*	<0.01*	0.99
GuttaFlow Bioseal-TotalFill BC Sealer	<0.01*	<0.01*	<0.01*	0.99
GuttaFlow Bioseal-AH Plus	<0.01*	<0.01*	0.40	0.07
Bioroot RCS-TotalFill BC Sealer	<0.01*	<0.01*	<0.01*	1
BioRoot RCS-AH Plus	<0.01*	<0.01*	<0.01*	0.19
TotalFill BC Sealer-AH Plus	<0.01*	<0.01*	<0.01*	0.21

*Tukey post-hoc test at the level of significance p<0.05

due to its discoloring effects on the tooth structure, in the latest version of MTA Fillapex bismuth trioxide was replaced with calcium tungstate (14). This replacement might be the cause of the decrease in radioopacity value of MTA Fillapex which leaded different radioopacity values in different studies. In recent studies, results of the latest version of MTA Fillapex (containing calcium tungstate) reported notably lower radioopacity values ranging from 2.7 mmAl to 5.25 mmAl (4,12,15), in contrast to older studies such as 8.9 mmAl reported by Tanomaru-Filho et al (13).

Root canal sealers should have low solubility for a successful endodontic treatment in long-term. Resolution of sealers shouldn't exceed 3% mass fraction according to the ISO standards (7). In the present study, TotalFill BC Sealer (7.63%) and MTA Fillapex (5.57%) showed significantly higher solubility than the other tested sealers ($p<0.01$). Dia-Root Bio Sealer and BioRoot RCS showed solubility rates 0.06% and 1.93% consistent with ISO requirements. On the other hand, AH Plus (-0.06%) and GuttaFlow Bioseal (-3.56%) showed no dissolution. The high solubility of bioceramic-based sealers may be due to the hydrophilic nature of these materials whereas AH Plus is a hydrophobic material, so its solubility rate is very low compared to bioceramic-based sealers. All the measured solubility rates are in accordance with previous studies with the exception of GuttaFlow Bioseal. The reported solubility rates of TotalFill BC Sealer are ranging from 7.44% to 13.12% (6,11,16,17). Although there are studies reporting that the solubility of MTA Fillapex is less than 3% (15-20), there are also other reports giving the solubility rate of MTA Fillapex higher than 3% up to 25.69% (5,12,21,22). The increasing solubility of MTA Fillapex can be attributed to the change in the composition of the sealer. Tanomaru-Filho et al. (12) used MTA Fillapex, which contained calcium tungstate instead of bismuth oxide and reported the solubility rate of 25.69%. In the case of solubility of BioRoot RCS there are conflicted reports ranging from 1.17% to 37.6 % (5,20). In present study, solubility rate of BioRoot RCS measured as 1.93% as stated in above, which falls in the range of reported solubility rates of previous studies. This wide range of reported solubility rates of BioRoot RCS could be attributed to different experiment settings. Prüllage et al. (20) used stainless ring molds with an internal diameter of 20 mm in contrast to 8 mm specimens found in Siboni et al. (5). The solubility rates of GuttaFlow Bioseal are ranging from -0.75% to 3.03% (15,23). In this study, the solubility of GuttaFlow Bioseal was found to be -3,56% different to the results in previous studies. This might be due to differences in the methods used in the solubility test. In some studies, the samples were kept in distilled water for 7 days instead of 1 day and then kept in a dehumidifier for 24 hours before the solubility test (11,23,24). The conflicting results in the studies can be explained by the duration, the samples spent in distilled water and the differences in the drying methods applied to them before the solubility test.

Flow is an important factor for the root canal sealer to reach spaces such as lateral canals and irregularities that the core material cannot fill. There are different factors such as particle size, composition, shear rate, temperature and time from mixing that affect the flow rate (18). According to the ISO standards, root canal sealers should have a flow rate above 20 mm (7). In the present study, all the tested sealers exhibited a flow rate above 20 mm in compliance with the ISO standards. TotalFill BC Sealer showed the highest flow rate with 29.7 mm, which was in accordance with reported measurements of Kwak et al. (8) and Katakidis et al. (25). All bioceramic-based sealers exhibited greater flow rates than AH Plus except for GuttaFlow Bioseal. Relatively high flow rates of bioceramic-based sealers could be related to nano-sized particles of calcium silicates and zirconium. The lowest flow rate belonged to GuttaFlow Bioseal with 22.78 mm. The reason why GuttaFlow Bioseal has a lower flow rate can be related to the its specific composition which contains relatively large particles compared to other bioceramic-based sealers (26). The measured flow rate was in accordance with Tanomaru-Filho et al. (11) and Lin et al. (27) which reported the flow rate of GuttaFlow Bioseal as 16.88 mm and 25.73 mm respectively. Contrary to these studies, Lopes et al. (15) and Camargo et al. (23) reported the flow rate of GuttaFlow Bioseal as 34.43 mm and 35.4 mm respectively. This difference in flow rates can be attributed to the setting of their experiment. Both researchers used American Dental Association standards in which the volume of experimented sealer was 0.5 mL instead of 0.05 mL (28). The high flow rate in these studies may be related to the higher amount of sealer used.

Dimensional stability of root canal sealers is another important factor in success of endodontic treatment. Although minimum shrinkage is expected, excessive expansion may cause root fractures. According to the ISO standards the maximum expansion rate should be 0.1% and the maximum shrinkage rate should be 1% (7). In the present study, all tested sealers demonstrated higher expansion rates than recommended by ISO with the exception of MTA Fillapex. MTA Fillapex showed a shrinkage rate of 0.60% which fell in the interval defined by ISO standards. In the literature, previous studies have reported different values for the dimensional change rate of MTA Fillapex, ranging from -5.4% to -0.67% (15,18,21). The variation of these reported dimensional change rate was expected considering that some researchers even excluded MTA Fillapex in their measurements. Regarding to this, Lee at al. (10) reported that MTA Fillapex was not completely set in humid incubator even after one month and they had to exclude MTA Fillapex sealer from their study. The dimensional change rates for GuttaFlow Bioseal were reported between -0.68% and 3.23% in different studies (11,15,23,27). The result of the present study was also in this range with the rate of 1.96%. In the literature, there is only one study reporting the dimensional change rate of BioRoot RCS as 1.23% in accordance with the present study (27). Among the tested root canal sealers in the present study, AH Plus showed the most constant mass similar to the previous studies results (6,10,11,18). The dimensional change test of root canal sealers relies on the measurements of height of sample but in real world changes in dimension occur in three dimensions. The width and the breadth of the samples also undergo a dimensional change. Therefore, using techniques such as micro-computed tomography which can measure the volume change, may yield more meaningful results for dimensional change test.

The null hypothesis was rejected in this study indicating that Dia-Root Bio Sealer did not exhibit better physicochemical properties than other tested sealers regarding radioopacity, solubility, flow and dimensional change. The radioopacity value of Dia-Root Bio Sealer was lower than TotalFill BC Sealer and AH Plus and there was no significant difference among radioopacity values of Dia-Root Bio Sealer, GuttaFlow Bioseal and BioRoot RCS (Table 3). Although Dia-Root Bio Sealer showed lower solubility than other bioceramic-based sealers, there was no significant difference between it and AH Plus (p=0.98). The flowability of Dia-Root Bio Sealer was higher than GuttaFlow Bioseal and AH Plus, but no significant difference was observed between it and BioRoot RCS (p=0.74). In terms of dimensional change, Dia-Root Bio Sealer showed significantly lower values than other bioceramic-based sealers except for MTA Fillapex (Table 2).

Study Limitations

In this study, the physical properties of some bioceramic-based root canal sealers were evaluated *in vitro*. *In vivo* conditions may affect the physical properties of these sealers.

Conclusion

Dia-Root Bio Sealer is a recently introduced bioceramic-based sealer and there is no study in literature regarding its physical properties. This study's results showed that Dia-Root Bio Sealer had adequate radioopacity, solubility and flow complying with ISO standards similar to AH Plus. In addition to this, both sealers exhibited similar dimensional change rates validated by statistical tests. According to the result of this study, Dia-Root Bio Sealer showed comparable physical characteristics with AH Plus and might be preferred in clinical applications.

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Ethics

Ethics Committee Approval: Ethics committee approval is not required.

Informed Consent: Informed consent is not required.

Authorship Contributions

Concept: N.G., Design: N.G., Data Collection or Processing: D.B.M., N.G., Analysis or Interpretation: D.B.M., Literature Search: D.B.M., Writing: D.B.M., N.G.

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