

# PENETRATION DEPTH OF RECENT BIOCERAMIC ROOT CANAL SEALERS TO DENTIN: AN IN VITRO STUDY

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DOI: 10.21608/dsu.2025.336568.1274 Manuscript ID: DSU-2411-1274

# KEYWORDS

Bioceramic, Bio-C Sealer, Penetration Depth

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#### **ABSTRACT**

Background: Bioceramic sealers have been developed for 30 years to be used in endodontics, they are ceramic materials that include zirconia, alumina, glass ceramics, bioactive glass, calcium phosphate and hydroxyapatite with superior biological and physical properties. Aim: To determine the effect of CeraSeal and Bio-C Sealer on penetration depth in a comparison with AH Plus using confocal laser scanning electron microscope (CLSM). Material and methods: This research was approved by the ethics committee of Suez Canal University-Egypt (No.256 /2020), thirty-three single rooted human premolars were extracted, collected and divided randomly into three groups according to sealer type AH Plus, Bio-C Sealer and CeraSeal. Each group (n=11), before obturation, Rhodamine B dye was mixed with each sealer, then obturation done using single cone technique, after that the samples were cut in cross-sectional direction at (3, 6 and 9 mm) to determine the depth of penetration using CLSM. Results: For the maximum depth of penetration, Bio-C Sealer showed the maximum penetration, with no statistically significant difference between the three sealers. While the results of penetration %, showed that the Bio-C sealer had the best penetration percentage with statistically significant difference between the three sealers. Conclusion: Within the limitations of this study, Bio-C sealer showed the best penetration into dentinal tubules between the tested sealers.

## **INTRODUCTION**

Three-dimensional obturation of root canal is important to obtain a high success rate of non-surgical root canal treatment <sup>(1)</sup>.

Hermetic seal of the obturation system is mandatory to reduces coronal leakage, bacterial contamination, prevent apical periodontitis and block the remaining bacterial remnants in the root canal <sup>(2)</sup>.

Endodontic sealers play a critical role in obturation of root canals in conjunction with gutta-percha to enhance sealing the main, lateral and accessory canals, seal voids and irregularities, creating a bond between gutta-percha and root canal wall, lubricating the root canal that allow easy introduction of gutta-percha, as well as having antibacterial effect<sup>(3)</sup>.

Sealer penetration is an essential property<sup>(4)</sup> as it decreases the possibility of microleakage. Resin based sealers are the most popular to be used due to their low solubility and good apical sealing ability, but their main disadvantages are cytotoxicity, mutagenicity and

hydrophobicity<sup>(5)</sup> to overcome these problems, calcium silicate-based sealers have been developed.

Bioceramic sealers have been developed for 30 years to be used in endodontics, they are ceramic materials that include zirconia, alumina, glass ceramics, bioactive glass, calcium phosphate and hydroxyapatite with superior biological and physical properties. They are biocompatible with surrounding tissues and can induce chemical reaction with hydroxy apatite of tooth structure which will improve the bond of sealer-to-root dentin. This study compared new calcium silicate-based sealers, CeraSeal (Meta-BioMed, Co., Cheongju, Korea), and Bio-C Sealer (Angelus, Londerina, PR, Brazil) with the gold standard resin-based sealer AH Plus, using a confocal laser scanning microscope (CLSM) to obtain the depth of sealer penetration into dentinal tubules.

This study was applied to determine the effect of CeraSeal and Bio-C Sealer on penetration depth in a comparison with AH Plus using a confocal laser scanning electron microscope (CLSM). The null hypothesis would be that no significant difference between all tested sealers in their penetration depth.

#### MATERIALS AND METHODS

This study was approved by the Research Ethics Committee (REC) (Approval no. 256/2020). Thirtythree recently extracted sound human single rooted premolars were disinfected in sodium hypochlorite (5.25%), then stored in 10% natural buffered formalin at room temperature to preserve their humidity. Followed by equal and random division of samples into three groups (n=11) according to type of sealer used.

All teeth were decoronated at 1mm coronal to the junction between enamel and cementum, to standardize root samples of 12mm length, using a low-speed diamond disk (Dica, Dendia, USA) under copious amount of water irrigation. Canal patency was checked using #10K file, then the working length for each tooth was obtained, Preparation of canals was completed using TruNatomy rotary file system (Dentsply Sirona, Ballaigues, Switzerland) at 500 rpm and 1.5 torque till final apical diameter reach #35 taper 0.04. Irrigation was done using 3ml of 2.5% sodium hypochlorite between each file with total volume 15 ml per each sample using (#30 gauge) side vented endodontic needles.

Final irrigation was done using 2 ml of 17% EDTA for 1 minute to remove smear layer, followed by final rinsing using 5ml of distilled water, then canals dryness was obtained using multiple sterile absorbent paper points.

#### **Penetration depth of sealers**

#### I- Obturation of root canal specimens:

Before obturation, the three sealers were mixed first with the Rhodamine B dye 0.1% (Sigma-Aldrich, ST, Louis, MO, USA). To be standardized, 10 parts of sealer were mixed with 1part of dye solution. Then the sealer was introduced into root canals using #35 taper 0.04 gutta-percha master cone in a single cone technique.

#### **II-Preparation of specimens for CLSM**

After obturation, the root samples were sectioned cross sectionally at 3mm, 6mm and 9mm starting from apex using IsoMet 4000 microsaw under copious amount of water, finally the sample sections were examined under CLSM (Leica DMi8, Germany).

For statistical analysis, ANOVA test (one and two way) was applied followed by post hoc test and  $p \le 0.05$  was considered statistically significant.

Pearson correlation was conducted to determine the correlation between penetration %, and maximum penetration.

Groups	AH Plus	<b>Bio-C Sealer</b>	CeraSeal
Coronal			
Middle			
Apical			

Fig. (1) Confocal laser scanning microscope images of sealer penetration into dentinal tubules of the three groups

### RESULTS

For maximum depth of penetration, Bio-C Sealer showed the maximum penetration followed by CeraSeal and then AH Plus with no statistical difference between the three sealers. For each sealer the depth of sealer penetration increased in an apicocoronal direction. For penetration %, Bio-C showed the highest penetration %, followed by CeraSeal and then AH Plus showed the lowest penetration %, with statistically significant difference between the three sealers. There was a strong positive correlative result between maximum penetration depth and the penetration percentage for the three groups of sealers (Table 1).

**Table** (1) Correlation of maximum penetrationdepth results and the penetration percentage resultsfor the three groups.

	r**	P-value	Correlation type
AH Plus	0.917	0.001 <sup>HS</sup>	Strong positive
Bio-C	0.786	<b>0.012</b> <sup>s</sup>	Strong positive
CeraSeal	0.853	<b>0.003</b> <sup>s</sup>	Strong positive

#### DISCUSSION

Various types of root canal sealers have been widely used in the dental market. Clinicians select their sealers according to their properties. The most optimal root canal sealer must be biocompatible and with low surface tension so that it can be introduced into irregularities as well as an appropriate wetting to provide fluid tight seal <sup>(4)</sup>.

Better penetration into the canal irregularities and dentinal tubules could be obtained by placing a high volume of gutta-percha combined with a minimal volume of sealer <sup>(6)</sup>.

Degree of adhesion and penetration of sealers into dentinal tubules is affected by several factors such as physical and chemical properties of sealer type, dentin permeability, obturation technique, and smear layer removal <sup>(7)</sup>.

This in-vitro study compared two recent bioceramic sealers (Bio-C Sealer and CeraSeal) with the resin-based sealer (AH Plus), in their penetration into dentinal tubules. AH Plus is used mostly in clinical work and is usually chosen as a control to study the properties of new sealers due to its good flowability, proper film thickness, and viscosity <sup>(8)</sup>.

Confocal laser scanning electron microscope (CLSM) is a widely used method for evaluation of the penetration ability of sealers <sup>(9,10)</sup>. As it could allow viewing details of the presence and distribution of sealers inside dentinal tubules along the canal circumference of each sample using fluorescent dye, it has the advantage of assembling many optical sections, even from thick specimen <sup>(11)</sup>. Also, the samples under CLSM can be visualized in various depths <sup>(12)</sup>.

Rhodamine B fluorescent dye has been used as an indicator under CLSM as it allows identification of sealers into dentinal tubules without affecting the physical properties of the sealers, in case of using small amount of dye (less than 0.2%) is mixed with the sealers <sup>(10)</sup>. Some studies advocated maximum penetration<sup>(13)</sup>. Others used penetration percentage <sup>(14)</sup>. We applied both methods in this study to reproduce more reliable results <sup>(15)</sup>.

The null hypothesis of this study was partly denied, for the three sealers maximum penetration, there was no statistical difference between coronal, middle and apical third in penetration. Although the maximum penetration was the highest coronally then decreased in the middle third and showed the least values in the apical third. This came in contact with the fact of higher number of dentinal tubules in the coronal third as well as their diameter is larger allowing for more sealer penetration, as well as the formation of sclerotic dentin and cementum-like structure apically might reduce sealer penetration <sup>(16)</sup>. This result agreed with <sup>(11,10)</sup> who reported less sealer tubule penetration apically than other root canal thirds.

There was no statistically significant difference between the three sealers in their maximum penetration. Taking into consideration that Bio-C Sealer showed the maximum penetration values followed by Ceraseal, while AH Plus showed the least value of maximum penetration. This result agreed with <sup>(10)</sup> who reported better dentinal tubule penetration of Bio-C Sealer than AH Plus. But it was against <sup>(17,18)</sup>.

For the three sealers penetration percentage, statistics showed considerable difference between coronal, middle and apical thirds, with the higher percentage of penetration was recorded at the coronal third then gradual decrease at the middle and then the least penetration values were at the apical third. This was mainly due to the histological characteristics of the apical root dentin, described as sclerotic and poorly permeable dentin that has fewer dentinal tubules compared to middle and coronal thirds dentin <sup>(11)</sup>. These results were consistent with studies <sup>(17,10,19)</sup>.

There was a statistically significant difference between the three sealers. With the maximum penetration percentage in Bio-C followed by CeraSeal then AH Plus in all the three thirds. These results were in agreement with (10) who showed that bioceramic sealers have greater tubule penetration than AH Plus. While these findings were against other studies (17,11,19,20). High penetration of Bio-C Sealer might be related to its high flowability due to its consistency and nanometric particle size as it is less than 2µm according to its manufacturer, which improves sealer penetration into irregularities of root canal systems (2). As in previous studies <sup>(21,22)</sup> Bio- C Sealer showed higher flowability than Ceraseal. Also, according to (20) CeraSeal did not meet the ANSI/ADA standardization of flowability. In contrast, AH Plus having larger particle size, polymerization shrinkage or problems during mixing might reduce its permeability into the dentinal tubules, the proportions and mixing process of sealers might be a key point in the tubule penetration of sealers (10).

Finally, by correlating interfacial gap results to the penetration percentage, there was a positive correlation. The previous result was inconsistent with a recent published study <sup>(23)</sup>, where they found that there is no correlation between interfacial gap and penetration percentage. Different assessment method might be the reason, as they used SEM to detect both parameters. In the current study, independent models were conducted.

# CONCLUSION

According to the parameters of this study, it was concluded that Bio-C sealer showed the most optimal penetration into dentinal tubules of the tested sealers.

#### **Declaration of competing interest**

#### **Conflicts of interest**

There are no conflicts of interest

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