A Comparative Study of Physical Properties and Interfacial Adaptation After Monoblock Obturation Using Bio GP Points with Bioceramic Sealer Versus Resinated Gutta-Percha Points with Resin Sealer (An In-Vitro Study)

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ABSTRACT

The Purpose:

This study was conducted to evaluate and compare the physical properties of a resin-based sealer (AH-Plus) used in conjunction with resinated gutta-percha to a bioceramic-based sealer (Sure Seal Root BC sealer) used in conjunction with bioceramic impregnated gutta-percha, and the effect of both sealers on interfacial adaptation to root dentin.

Methodology:

Thirty-six single rooted extracted human mandibular premolars were prepared using Hyflex rotary system with 2.5% NaOCl irrigation. The specimens were randomly distributed into two groups according to the gutta-percha and sealer used; Group 1: Bio GP Points and Sure-Seal Root Bioceramic sealer, and Group 2: Resinated gutta-percha points and AH-Plus resin sealer. All samples were obturated using the single cone technique. For assessment of the push-out bond strength, roots were sectioned horizontally to obtain 2 mm-thick discs from the coronal, middle and apical thirds, then discs were subject to a compressive load via the universal testing machine until bond failure occurred. Regarding fracture resistance evaluation, vertical root fracture was performed for all specimens using a universal testing machine, and the force required to fracture the roots was measured in Newtons. For interfacial adaptation assessment, teeth were sectioned longitudinally and examined using Field Emission Gun-Scanning Electron Microscope (FEG-SEM).

Results:

The resin group showed a significantly higher bond strength in the coronal third than the bioceramic group (p<0.001), with no significant difference in the middle (p = 0.936) and apical thirds (p = 0.444) between the two groups. Regarding fracture resistance, no significant difference was detected between the two groups (p = 0.817). FEG-SEM analysis revealed that AH-Plus resin sealer showed complete marginal adaptation with no gaps at dentin-sealer interface. Similarly, the Sure-Seal Root BC sealer showed complete marginal adaptation to root canal dentin at middle and coronal thirds. Whereas, at the apical third of bioceramic sealer samples, minimal gaps were detected.

Conclusions:

Within the limitations of this study, the use of both resin and bioceramic sealers in root canal treatment showed comparable vertical root fracture resistance and bond strength at the middle and apical thirds of the root. AH-Plus resin sealer demonstrated superiority in its bond strength values at the coronal root third when compared to that of Sure Seal Root BC sealer. Furthermore, the apical sealing ability of resin sealers is better than that of bioceramic sealers.

Keywords:

Bioceramic sealer, bond strength, fracture resistance, impregnated gutta-percha, interfacial adaptation, resin sealer, scanning electron microscope

DOI: 10.48047/ecb/2023.12.Si8.776

INTRODUCTION:

Clinical performance and success of endodontically-treated teeth is strongly related to the biomechanical events involved during all phases of endodontic treatment.[1] Three-dimensional obturation of the root canal system is the final phase of endodontic treatment and one of the most important factors for long term success of root canal therapy, as it aims to provide a gap-free interface between root canal filling materials and radicular dentin.[2]

Chemo-mechanical preparation of the root canal system aims at eliminating microorganisms and preventing canal re-infection, however, it results in loss of intra-radicular dentin and changes the mechanical properties of the tooth, which increases the susceptibility of the tooth to fracture. Therefore, the use of obturating materials that strengthen the root and compensate for this weakening effect is mandatory.[3] The widely accepted root canal obturation technique involves the use of gutta-percha cones as the core material in association with root canal sealers.[4]

Adhesion of a root canal sealer refers to its ability to adhere to the root canal walls and seal the gap between the core filling materials and root dentin in order to form a single unit achieving the monoblock concept, consisting of a continuous bond among the root dentin, core material and root canal sealer that is believed to enhance the sealing ability and reinforce the residual root structure against vertical fracture.[5]

Epoxy resin-based root canal sealers were introduced to overcome the limitations of the traditional zinc oxide eugenol-based sealers.[6] Adhesion to dentin was achieved by covalent bond formation between the reactive epoxide group of the sealer and the exposed amino groups in the collagen network.[4] They have been successfully used for many years because of their excellent apical sealing ability, good physical properties and adequate micro-retention to root dentin.[7]

Bioceramic-based root canal sealers have been used in the field of endodontics for the past years. These sealers are dimensionally stable with excellent physical properties since they utilize the moisture naturally present in the dentinal tubules to initiate and complete the setting reaction.[8]

Many studies have assessed the physical properties and adaptation of different root canal sealers, but few discussed the effect of monoblock achieved by coated gutta-percha and its corresponding sealer on these properties. Thus, this in-vitro study was conducted to evaluate and compare the physical properties of a resin-based sealer used in conjunction with resinated gutta-percha to a bioceramic-based sealer used in conjunction with bioceramic impregnated gutta-percha, and the effect of both sealers on interfacial adaptation to root dentin.

Materials and Methods:

36 extracted human mandibular premolar teeth of patients within the age group of 18–40 years, 12 for each outcome, exhibiting straight, single root canal, single apical foramen, with no cracks, caries, restoration, internal or external root resorption, pulpal calcifications or abnormal canal morphology on radiographic examinations were chosen. The study protocol was reviewed and approved by the Research Ethics Committee in Cairo University. The collected samples were concealed, randomized and allocated using (www.random.org) website.

For all samples, access cavity was prepared, working length and canal patency were determined. Instrumentation was done employing the crown-down technique using Hyflex rotary system, starting with file size 25/0.08 to perform the coronal flare and finishing with file size 40/0.04. At the end of mechanical preparation, canals were flushed with 5 ml saline solution and dried with paper points size 40/0.04 equivalent to the master apical file. Prepared teeth were randomly classified into two groups according to the GP and sealer used.

-Group 1; root canals were obturated with Bio GP Points in conjunction with BC sealer (Sure Seal Root BC sealer)

-Group 2; root canals were obturated with Resinated GP Points in conjunction with Resin sealer (AH-Plus)

All samples were obturated using SC technique with GP cones size 40/0.04 corresponding to the size of the master apical file. Following obturation, root canal entrance was sealed with temporary filling material with a sufficient thickness of 3 mm. Samples were examined radiographically in both labio-lingual and mesio-distal directions to ensure homogenous adequate root filling without voids and confirm the quality of obturation. All samples were kept on gauze pads at 37ºC and 100% relative humidity for one week to allow complete setting of the sealers

For assessment of the push-out bond strength, roots were horizontally sectioned to obtain 2 mm-thick discs from the coronal, middle and apical thirds, then discs were subject to a compressive load via the universal testing machine until bond failure occurred.

Regarding fracture resistance evaluation, vertical root fracture was performed on all specimens using the universal testing machine, and the force required to fracture the roots was measured in Newtons.

For interfacial adaptation assessment, teeth were longitudinally sectioned into two halves. The half of each specimen which retained the obturation material was chosen for examination using Field Emission Gun-Scanning Electron Microscope (FEG-SEM). Interfacial adaptation and marginal gaps were evaluated at the apical, middle and coronal root thirds at 1500x magnification.

Data were tested for normality using Kolmogrov – Smirnov test and Shapiro – Wilk test. Data were presented as mean and standard deviation (SD) values. Comparison between the two groups were performed using independent *t* test, while comparisons between the different root levels within the same group were performed using ANOVA and Tukey post hoc tests. The level of significance was set at p = 0.05. Statistical analysis was performed using SPSS software (IBM Corp. Released 2017.

IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.)

Results:

1. Push-Out Bond Strength

1.1. Push-Out Bond Strength between the two groups:

1.1.1. In the coronal third:

The mean and standard deviation values of push-out bond strength in the coronal third were 0.5 ± 0.4 MPa in the BC group and 3.7 ± 0.7 MPa in the resin group. There was a significant difference between the two groups (*p*< 0.001).

1.1.2. In the middle third:

The mean and standard deviation values of push-out bond strength in the middle third were 1.8 ± 1.5 in the BC group and 1.9 ± 1.8 in the resin group. There was no significant difference between the two groups (*p* = 0.936).

1.1.3. In the apical third:

The mean and standard deviation values of push-out bond strength in the apical third were 2.2 ± 1.3 in the BC group and 1.7 ± 0.7 in the resin group. There was no significant difference between the two groups (*p* = 0.444).

1.1.4. Push-Out Bond Strength within each group:

1.1.5. Within the BC group:

Within the BC group, the mean push-out bond strength was 0.5 ± 0.4 MPa in the coronal third which increased to 1.8 ± 1.5 MPa in the middle third, then, finally increased to 2.2 ± 1.3 MPa in the apical third. There was no significant difference in the push-out bond strength between the coronal, middle and apical thirds (*p* = 0.069).

1.1.6. Within the Resin group:

Within the resin group, the mean push-out bond strength was 3.7 ± 0.7 MPa in the coronal third which was significantly reduced to 1.9 ±1.8 MPa in the middle third then finally to 1.7 ±0.7 MPa in the apical third. There was a significant difference in the push-out bond strength between the three thirds (*p* = 0.015).

The coronal third showed significantly higher push-out bond strength than the middle and coronal thirds. On the other hand, there was no significant difference between the middle and apical thirds.

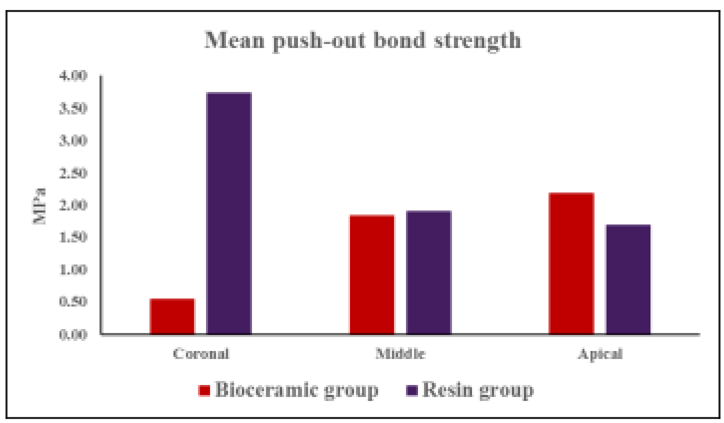

Fig. (1) Bar chart representing the mean push-out bond strength at different root levels in the two groups

Fracture Resistance

The mean and standard deviation values of fracture resistance were 502.6 ± 171.4 in the BC group and 521.7 ± 97.1 in the resin group. There was no significant difference between the two groups (p = 0.817).

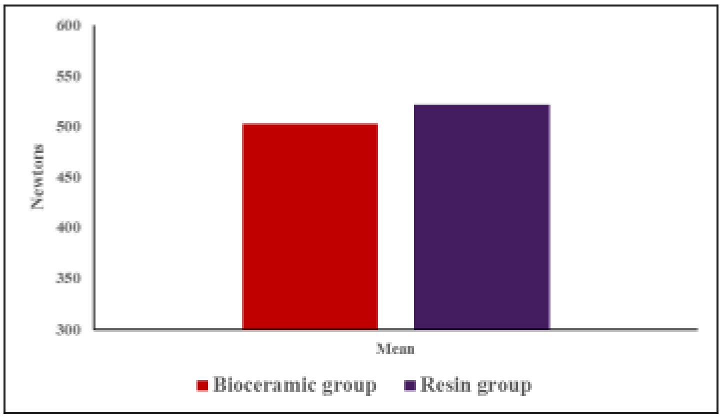

Fig. (2) Bar chart representing the mean fracture resistance in the two groups

2. Interfacial Adaptation

AH-Plus resin sealer showed complete marginal adaptation with no gaps at dentin-sealer interface, at the three levels. Similarly, the Sure-Seal Root BC sealer showed complete marginal adaptation to root canal dentin at middle and coronal thirds. Whereas, at the apical third of BC sealer samples, minimal gaps were detected with a maximum mean average gap of 1.677µm. Sure-Seal Root BC sealer appeared to have a uniform appearance with small granular structure, while for AH-Plus Resin sealer, it appeared to have a granular appearance of varying size particles within epoxy-based resin matrix.

Discussion:

In this study, two root canal sealers with different adhesion properties were tested. Sure-Seal Root BC sealer which is hydrophilic in nature, where root canal wall and tubule moisture is necessary for its setting.[8] The second sealer used was AH-Plus root canal sealer which belongs to the resin-based materials that has the ability to bond to radicular dentin and penetrate deeply into the dentinal tubules.[7]

The study was conducted on single-rooted mandibular premolars with standardized root length of 14 mm to ensure maximum standardization of the experimental groups.[9] All canals were obturated with the single-cone technique, as it provides more uniform mass of gutta-percha and decreases the sealer amount which in turn minimizes the possibility of gap formation due to sealer shrinkage or dissolution.[10]

Push-out bond strength test has been commonly used to evaluate the adhesion potential of different root canal filling materials and systems to root canal dentin.[11] The load has always been applied in an apical-coronal direction to avoid any constriction interference caused by root canal taper during push-out bond testing.[9] The difference in the coronal bond strength between the two groups of the present study can be explained by the higher tubular density in the coronal third compared to the middle and apical thirds which increases the number of the resin tags, enhancing AH-Plus bond strength.[12] This is in agreement with the SR of **Silva et al. (2019)**[13], where they referred the good resistance of AH-Plus to dislodgment to its ability to bond chemically to radicular dentin, since they are hydrophobic in nature, having reactive terminal epoxide rings that can react with the exposed amino groups in the collagen network forming covalent bonds. Other studies[(4,14)] reported that the high bond strength values of AH-Plus could be due to its low polymerization shrinkage, long-term dimensional stability and the slightly acidic pH associated with potential chemical bonding due to ring opening. On the other hand, **Yap et al. (2017)[15]** and **AL-Hiyasat et al. (2019)[16]** reported that obturation with BC sealer showed higher bond strength than AH-Plus. They attributed their results to the high flowability of BC sealer which leads to deeper penetration into dentinal tubules forming tag-like structures at the sealer-dentin interface for micromechanical interlocking. It also has the ability to slightly expand upon setting due to its hydrophilic property; resulting in greater adhesion. Additionally, the BC sealer chemically interacts with the radicular dentin forming mineral infiltration zone by infiltration of the sealer's mineral contents into the intertubular dentin, after denaturation of the collagen fibers by the strong alkaline sealer.

The results of the present study showed that AH-Plus Resin sealer had higher vertical root fracture resistance than the Sure-Seal Root BC sealer but with no significant difference between them (p= 0.817). These results are in accordance with the SR of **Uzunoglu-Özyürek et al. (2018)[17]** and the previous studies of **Osiri et al. (2018)[18]** and **Alkahtany et al. (2021)**[19]. A multiple of reasons were suggested for this outcome, including the adhesive properties of the sealer and its bioactivity. They related the high fracture resistance of AH-Plus to the formation of a covalent bond between the open epoxide ring and exposed amino acids in the collagen. Moreover, AH-Plus possesses an excellent penetration ability into the surface micro-irregularities due to its creeping property and long polymerization period, which increases the mechanical interlocking between the sealer and root dentin, resulting in increased fracture strength.

The high fracture resistance of BC sealer was explained by its ability to produce hydroxyapatite, which leads to increased chemical bonding of sealer to the canal dentinal walls. In addition, the presence of small "nanoparticles" and their ability to penetrate deeply into isthmuses, accessory canals and canal irregularities also justifies the higher fracture strength of BC sealer.

Analysis of the different adaptation of sealers to canal walls and marginal gaps were assessed with Field Emission Gun-Scanning Electron Microscope (FEG-SEM) because the defects at the submicron level are often observed at high magnification.[7] Interfacial adaptation and marginal gaps were evaluated at the apical, middle and coronal root thirds at 1500x magnification, similar to the previous studies of **Nakamura et al. (2012)[20]** and **Huang et al. (2018)**[21]. In the present study, we evaluated the adaptation of a BC sealer with BC impregnated GP to root canal walls and compared it with that of an epoxy resin-based sealer with resin impregnated GP in different root canal sections. Considering the results, only SureSeal Root BC group showed minimal interfacial gaps at the apical third of the root canals. This observation was in consistency with those of the previous studies of **Al-Haddad et al. (2015)**[22], **Chen et al. (2017)[23]** and **Arikatla et al. (2018)**[2]. They related this discrepancy to the lower density and diameter of dentinal tubules found at the apical level, resulting in lower sealer penetration. With respect to the middle and coronal root canal sections, both BC and epoxy resin-based sealers showed tight junction with tubules walls and no obvious gaps were observed. The results agreed with the previous studies of **Polineni et al. (2016)[24]** and **El Hachem et al. (2022)**[25]. These findings contradict the results of **Eltair et al. (2017)[26]** and **Hegde et al. (2020)**[27].

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