BOND STRENGTH OF BIOROOT RCS RELATIVE TO DIFFERENT ENDODONTIC BIOCERAMIC SEALERS: IN VITRO PUSH-OUT TEST

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ABSTRACT

The Aim of the study was to evaluate the bond strength of BioRoot RCS as compared to EndoSequence BC, MTA Fillapex, AH Plus, and Pulp Canal Sealer by using the push-out test EWT. Fifty 2-mm-thick discs were o btained from extracted single-rooted human teeth at different root levels: coronal, middle, and apical. The push-out tests were performed at a crosshead speed of 1 mm/min using an MTD-500 Plus machine. Values in megapascal were analyzed using one-way ANOVA and a post hoc test. BioRoot RCS demonstrated a significantly higher bond strength to root dentin than did the other sealers (3.2 MPa) [P < 0.05].

Keywords: *BioRoot RCS, Push-out bond strength, bioceramic endodontic sealers.*

INTRODUCTION

Root canal obturation is defined as " three dimensional filling of the root canal system as close to the cemento-enamel junction as possible" (American Academy of Endodontists, 1994). The nature and effectiveness of root canal sealers (RCS) are among the most important factors to be considered in obtaining adequate obturation of the complicated root anatomy, fill the gaps, and compensate for lack of adhesion of the root canal filling.[1]

Although multiple materials have been evaluated for their potential as RCS, zinc oxide- and epoxy resin-based sealers are currently the most frequently used. While zinc oxide-eugenol sealers feature antimicrobial properties[2] and resorption if extruded into periapical tissue[3], they also exhibit solubility and shrinkage on setting.[4] In addition to its low solubility and being eugenol-free, Resin based sealers were introduced as an alternative to enhance adaptation and adhesion to dentin.[5]

Recently introduced bioceramic sealers contain calcium phosphate, which enhances the final byproduct after setting and adopts an apetite-like structure that enhances bonding to dentin.[6] However, such materials are difficult to remove if retreatment or post-space preparation is required.[7] Among the bioceramic sealers, MTA Fillapex (Angelus, Londrina, Brazil) was the first introduced to demonstrate the favorable biological and sealing properties of MTA.[1] Other bioceramic sealers, such as BioRoot RCS (Septodont, Saint-Muar-des-Fossés, France) and EndoSequence BC (Brasseler USA, Savannah, Georgia, USA) were recently developed for their bioactivity and ability to produce mechanical bonds[8] and establish mineral infiltration zones.[9]

The BioRoot RCS is a hydraulic tricaclium-based cement that contains tricalcium silicate, zirconium oxide, calcium chloride, povidone, and polycarboxilate. It possesses a high antimicrobial activity and low cytotoxicity owing to the alkalinity of the sealer and prolonged release of Ca+ ions after setting, which in turn promotes endodontic and periodontal regeneration.[10] The BioRoot RCS has gained increasing interest for its ability to continue sealing in the presence of hydrophilic atmosphere by mineralization and apatite deposition at the root canal wall interface.[11]

Adhesion of root canal filling to the radicular dentin to establish a fluid-tight seal is one of the essential criterion for an ideal RCS.[1] Many studies evaluated the bond strength of various sealers using different methods. The push-out test has been used in dental research to test different dental materials.[12,13] This test measures interfacial shear bond strength between root dentin and the intracanal filling material by calculating the load required to dislodge the filling material using a pin with an appropriate pin diameter/filling diameter

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ratio.[14] Different methodological variables were reported to influence the push-out resistance to dislodgment of root canal filling that include; the type of sealer, core material, the thickness of the slices, storage time, tooth portion, and load velocity.[15] Although the push-out test was argued to measure the bonding strength of soft core material, it remains useful for ranking root canal materials[16] and inferring stress during post space preparation.[1]

To the best of our knowledge, no study has investigated the bond strength of BioRoot RCS using the push-out test. The present study therefore employed the push-out test to evaluate the bond strength of BioRoot RCS relative to different bioceramic sealers and two standard root canal epoxy resin-based and zinc oxide-based sealers.

MATERIALS & METHODS

Specimen Preparation

The present study was approved by the Institutional Review Board (IRB) from the College of Dentistry, King Saud University, Saudi Arabia (No. E-18-3004). Seventeen extracted human single-rooted teeth with a straight root canal were obtained and stored in 0.4% thymol. The teeth were decoronized and mounted on a surveyor to gain a straight canal system. Afterward, the teeth were embedded in acrylic resin (Dentsply DeTrey, Konstanz, Germany), which was mixed according to the manufacturer's instructions. Using a water coolant and a precision cutting machine (low-speed diamond saw: Isomet 200, Buehler, Illinois, USA), specimens were cut into 2mm-thick discs obtained from the coronal, middle and apical thirds of the root. The thickness of each disc was carefully measured with a digital caliper to confirm a uniform thickness of the specimens.

Preparation of the specimens' lumina was performed with a size 40/0.06 ProFile® (Dentsply Maillefer, Ballaigues, Switzerland) rotary system using the crown down technique. The lumina's preparation was standardized between D14 and D16 of the rotary files. The final major diameter of the lumen was 1.36mm, while the minor diameter was 1.24mm.

Following preparation, the specimens were flushed with 5.25% sodium hypochlorite, treated with 17% Ethylenediaminetetraacetic acid SmearClear® (SybronEndo, Orange, CA, USA), and finally rinsed with 0.9% sterile saline. The specimens' lumina were dried using sterile paper points. Fifty discs from three different thirds were randomly assigned to five groups for obturation with gutta percha and one of the five tested sealers (n=10): BioRoot RCS (Septodont, Saint-Muar-des-Fossés, France), AH Plus (Dentsply DeTrey, Konstanz, Germany), Endosequence BC (Brasseler USA, Savannah, Georgia, USA), Pulp canal EWT (Kerr, Italia Srl, Salerno, Italy), and MTA Fillapex (Angelus, Londrina, Brazil). Sealers were prepared according to the manufacturers' instructions. The matching gutta percha cone coated with the tested sealer was fitted in the lumen and cut with a sharp blade from the minor diameter, cut from the major diameter using System B at 250^{o} C, and packed using #11 schilder endodontic pluger (Dentsply Maillefer, Ballaigues, Switzerland). Specimens were radiographed to assure a compact obturation. Afterward, the teeth were stored in an incubator (INP500, Memmert GmbH, Western Germany) at 37^{o}C with 100% humidity.

After 7 days, the push-out test was performed using an MTD-500 Plus machine (Figure 1) (SD Mechatronik, Feldkirchen-Westerham, Germany). A given specimen was fixed onto a custom-made fixture in an orientation where the pin (diameter, 0.95mm) was pushing against the gutta percha on the minor diameter. The fixture was designed to allow for free movement of the dislodged gutta percha through the major diameter. The speed of the rod was 1mm/min until bond failure occurred. The load required to dislodge the gutta percha was recorded in Newtons. The bond strength was calculated in MPa by dividing the load (N) by the surface contact area (mm^2).

Statistical Analysis

The values of the bond strength were analyzed using a one-way ANOVA and a post hoc test. Statistical analysis was performed using SPSS software version #22 with the significance level set to ▯ = 0.05. The null hypothesis was that there was no significant difference in bond strength among the five tested root canal sealers.

RESULTS

The BioRoot RCS demonstrated a significantly higher bond strength than did the other four sealers. The AH Plus sealer featured a significantly higher bond strength than did the remaining three sealers ($p<0.05$). There was no significant difference between the EndoSequence BC and the Pulp Canal Sealer EWT ($p> 0.05$). The MTA Fillapex had the lowest bond strength to radicular dentin (Table1).

DISCUSSION

After having developed Biodentine, which featured favorable physical, biological and clinical properties for dentine restoration and root canal applications, the same active BioSilicate Technology produced BioRoot RCS as root canal sealer. To the best of our knowledge, this is the first study that compared the bond strength of BioRoot RCS to different calcium-silicate-based sealers and the long-established resin- and zinc oxide-based sealers. However, the results of the present study have to be interpreted keeping in view its limitations such as; its inability to estimate the amount of leakage of the BioRoot RCS. The homogenous adaptation between the dentin and the gutta percha is not affected by the tensile bond strength of the sealer because the point of contact between the sealer and the dentin might be

TABLE 1: MEAN DENTIN BOND STRENGTH VALUES OF THE FIVE TESTED ENDODONTIC SEALERS.

	Mean Bond Strength (MPa)		Standard Deviation
BioRoot	10	3.2[c]	0.2
EndoSequence	10	2.25[b]	0.2
AH Plus	10	2.8[a]	0.1
Pulp Canal Sealer EWT	10	2.1[b]	0.1
MTA Fillapex	10	1.1[d]	0.1

*Different superscripts indicate statistical significance

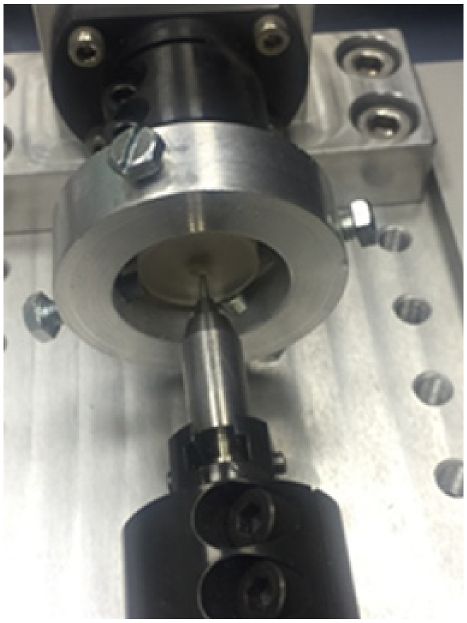

Fig 1: Testing apparatus.

interspersed with voids that lead to leakage.[5]

Bond strength can be measured using different techniques; microtensile, shear strength, pull-out, and push-out.[12] All of these tests were reported to have reproducible and effective results. However, the push-out test was reported to have additional advantages: ease of alignment, standardization of the specimen, and evaluation of the sealer despite low bond strength, as well as less sensitivity to small variations and the distribution of stresses when the force is applied.[12] The main disadvantage of the push-out test is its inability to reproduce exact clinical conditions. This is because the surface of the prepared walls during endodontic treatment differ considerably, and the root dentin is not uniform.[12] Moreover, multiple factors of the push-out test, such as pin diameter and specimen thickness, vary across studies. Chen et al[14] recommended that such factors be standardized to improve the comparison of results across studies that employ the push-out test. Past research used a 0.6 mm and 7.0 mm thickness of the specimen[12]; thin slices were preferable to create a larger number of samples and when a high value of bond strength is expected. However, Chen et al[14] reported that the push-out bond strength formula is more reliable when the specimen thickness is greater than 1.1 mm. The present study adjusted the factors to accommodate recent efforts to standardize measurements: a pin diameter/filling diameter ratio of less than 0.85 mm and a specimen thickness of 2-mm to prevent premature debonding.[12,14] Specimen discs were collected from the coronal, middle, and apical thirds of the root and randomly distributed among the test groups to minimize the effect of the difference in the dentin modulus of elasticity along the root length.[14]

The BioRoot RCS demonstrated the highest bond strength, followed respectively by AH Plus, EndoSequence BC, Pulp Canal Sealer EWT, and MTA Fillapex. Although no study has investigated the bond strength of BioRoot RCS, it has been reported that the bond strength of Biodentine as a filling material was the highest when compared alongside ProRoot MTA and BioAggregate.[9] Moreover, the present study noted difficulties in the means of flow of BioRoot RCS's material; which may affect contact points with the dentin and result in higher voids volume, which could be due to the short working time of the material.[17] The significantly higher bond strength of AH Plus relative to MTA Fillapex was reported in prior studies that used similar specimen thicknesses when conducting the push-out test.[18,19] Carvalho et al[20] compared the micro push-out bond strength of EndoSequence BC with that of AH Plus and concluded that the latter featured a significantly higher bond to root dentin. Lastly, the higher bond strength of the AH Plus relative to Pulp Canal Sealer EWT was reported at all levels (apical, middle, and coronal).[21]

MTA Fillapex is composed of a combination of resins, silica, and MTA. This composition gives the sealer properties similar to resin-based sealers and favorable physical properties of the original MTA. Moreover, MTA component affects the biological features and ability to release calcium ions.[22] Therefore, similarities between MTA Fillapex and AH Plus can be validated regarding their respective handling characteristics and pattern of failure due to the sealers' composition. However, the addition of resins to the MTA Fillapex sealer reduces the adhesion of apatite tag-like structures, which further leads to a diminished bond strength to root dentin.[19] The lower bond strength of the MTA Fillapex can also be attributed to its higher solubility relative to AH Plus.[23]

Several factors may account for the higher bond strength of Bioroot RCS: its zirconium oxide induces a higher release of calcium ions[24], and the penetration of the flowable cement through the open dentinal tubules and hydration process result in the formation of mineral infiltration zone, and improve its mechanical properties.[9] Further investigations are needed to clarify other physical properties of BioRoot RCS that may account for its increased bond strength.

CONCLUSIONS

The BioRoot RCS showed a higher bond strength to root dentin than AH Plus, EndoSequence BC, Pulp Canal Sealer EWT, and MTA Fillapex. Further studies are recommended to investigate the effect of other factors such as storage time, thickness of the slice, and root portion on bond strength of BioRoot RCS.

Acknowledgment

The authors wish to thank the College of Dentistry Research Center, King Saud University, for their support in conducting this project and; the Deanship of Scientific Research and RSSU at King Saud University for their technical support.

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