Comparative Evaluation of the Push-Out Bond Strength of Three Root Canal Sealers

Neetha Shenoy[1], Karthik Shetty[2]*, Vinod Jathanna[2], Kishore Ginjupalli[1], Keerthana Kunaparaju[2]

1. Department of Conservative Dentistry and Endodontics, Manipal College of Dental Sciences, Manipal, Affiliated to Manipal Academy of Higher Education, Manipal, Karnataka -576 104. India.
2. Department of Conservative Dentistry and Endodontics, Manipal College of Dental Sciences, Mangalore, Affiliated to Manipal Academy of Higher Education, Manipal, Karnataka -575 001. India.

Abstract

In this study, the bond strength of three root canal sealers, i.e., AH Plus, GuttaFlow 2 and BioRoot RCS to the intra-radicular dentin, was evaluated by the push-out test design. Thirty extracted teeth with single roots without fractures or defects, presenting with closed apices, were randomly divided into three groups, with each group containing ten samples. The samples were decoronated, standardizing the length of the samples to 15 mm uniformly. Canal instrumentation was done using ProTaper Universal rotary files upto size #F3 and lateral compaction technique was used for obturation with 2% taper standardized gutta-percha along with each of the three different sealers. After obturation and final setting of the sealers, the specimens were sectioned and observed under the stereomicroscope to check the integrity of the obturation and were then subjected to push-out bond strength test. The results of the test revealed that the push-out bond strength of BioRoot RCS was greater compared to AH Plus and GuttaFlow2, which was statistically significant with p<0.05. Push-out bond strength in the decreasing order was as follows: BioRoot RCS > GuttaFlow2 > AH Plus.

Experimental article (J Int Dent Med Res 2020; 13(4): 1304-1308)

Keywords: Push-out bond strength, Bioceramic sealers, Calcium silicates, Obturation, Sealer dentin interface.

Received date: 12 August 2020 **Accept date:** 11 October 2020

Introduction

The root canal sealer performs as the critical filler between the canal wall and the core in any obturation.[1] A reliable and durable seal is of paramount importance for successful obturation. Proper sealing would prevent remaining bacteria and their toxins to invade the root canal space which would contribute to the failure of endodontic therapy.[2]

The selection of sealers available to the clinician today is vast. But literature has shown that all sealers have their advantages and disadvantages, leaving the clinician the task of choosing the best options based on the data available. There are various parameters on which sealers have been assessed over the years. The resistance of the sealers to dislodgement is one of the most important parameters and has been shown to be related to leakage of root canal fillings according to the literature.[3, 4] Push-out bond strength testing was chosen as it is relatively simple to carry out and has been quoted as one of the best adhesion tests available.[5,6]

BioRoot RCS (Septodont, Saint-Maur-des-Fossés, France) a bioceramic sealer with excellent biocompatibility contains calcium silicates that form a layer at the interface of dentine called the “mineral infiltration zone”. It has been recommended for both lateral compaction and single cone obturations.[7]

GuttaFlow2 (Coltene /Whaledent, Langenau, Germany) introduced in 2012, is a self-curing, injectable silicon-based sealer, which is an evolution of GuttaFlow. Silicone based groups of sealers have shown good sealing ability because they are insoluble, show expansion and have excellent flowability. Studies conducted on GuttaFlow2 showed good biocompatibility and sealing ability.[8]

Corresponding author:
Dr. Karthik Shetty
Professor and Head of the Department,
Department of Conservative Dentistry and Endodontics,
Manipal College of Dental Sciences, Mangalore
Affiliated to Manipal Academy of Higher Education, Manipal
Karnataka -575 001. India
E-mail: karthik.shetty@manipal.edu

AH Plus (Dentsply, Konstanz, Germany) resin sealer has been studied extensively overtime.[9] It has been proven to provide a good seal due to its chemical bonding to the amino-terminal group of collagen in the dentine.[10]

This study assessed the push-out bond strength of three sealers: a tricalcium silicate sealer (BioRoot RCS), a poly-dimethylsiloxane sealer (GuttaFlow2) and a resin sealer (AH Plus).

Materials and methods

Study design

This was a prospective, single-blinded, in-vitro study. Ethical approval for the study was obtained from the Institutional Ethics Committee. (Protocol reference number: 17062). Based on the previous study by Paulson et al. [11] the sample size was estimated using Mead's resource equation: E = N-B-T where:

- N is the total number of samples in the study (minus 1)
- B is the blocking component, representing environmental effects in the design (minus 1)
- T is the treatment component, corresponding to the number of experiment groups (including control group) being used (minus 1)
- E is the component, corresponding to the degree of freedom of error.

Based on this, thirty teeth with ten samples per group were included.

Sample Preparation

Thirty freshly extracted human maxillary anterior teeth with single canal, a mature apex and a root canal curvature between 0-20 degrees (Schneider's method) were selected. Teeth with open apex, severe root curvature (>20 degrees), calcified canals and root caries were excluded from the study. The debris on the teeth samples was cleared off with the hand scaler and debrided with NaOCl. The samples were decoronated with a diamond disc (Horico, Germany) in the presence of water spray. The length of the samples was standardized to 15 mm, following which they were placed in normal saline.[12] The canals were initially instrumented with ISO #10 K (Dentsply, Maillefer, Switzerland) file to check the patency under 10X magnification using an operating microscope. The working length was determined radiographically and was adjusted to 1 mm short of the root apex according to Ingle's Method.

The canals were instrumented with ProTaper Universal system (Dentsply Tulsa Dental, Tulsa, OK) upto size #F3 (30/0.09). An ISO #10 K file was used alternatively during instrumentation up to the full working length. Irrigation was done with 3 mL of 5.25% NaOCl. Final irrigation was performed with 5 mL saline for 1 min and the canals were dried using absorbent paper points (Dentsply, Maillefer, Switzerland).

Randomization:

All the samples were labelled. By referring to a random number table, these samples were allocated to the following three groups with ten samples each.

Group I: AH Plus sealer
Group II: GuttaFlow2 sealer
Group III: BioRoot RCS sealer

The standardized #30 GP cone (Dentsply, Maillefer, Switzerland) was selected and the master cone fit was confirmed radiographically. The sealers were mixed following the instructions specified by the manufacturer. The canals were coated with the respective sealers (Table 1) and were filled with the master cone and accessory cones using the lateral compaction technique followed by a temporary restoration with Cavit G (3M ESPE, Germany) as a coronal seal. Periapical radiographs were taken to evaluate the obturation. The sample storage was done under 100% humidity at 37˚C for two weeks to facilitate setting of the sealers.

Push out bond strength test

The samples were sectioned 6 mm from the coronal end with a diamond disc to get 1 mm thick sections. To assess the integrity of the obturation, the sections were observed under a stereomicroscope at a magnification of 20X. Sections without voids and the canals with only circular cross-sections were included (Figure 1). A customized jig was fabricated with a hole beneath to contain the obturating material after dislodging from the canal.[13] Each sample was carefully positioned on the jig with the coronal end facing downwards. The stainless steel plunger was placed in such a way that it contacted only the root canal filling and was fixed at the upper end of the universal testing machine. The push-out assessment was executed at a crosshead speed of 1 mm/min on a universal testing machine (Instron 3366, Inston corp., Canton, USA) where compressive force was applied (apico-coronal direction) until the occurrence of bond fracture which exhibited as a rapid drop along the load-deflection with the extrusion of obturation material. The maximum load of fracture was measured in newtons and the bond strength value in megapascals.

Figure 1. Stereomicroscopic image of the obturated specimen showing gutta-percha cones and sealer.

Sealers	Composition	Manufacturer	Working Time	Setting time	Ability to bond with dentin	Calcium ion release
AH Plus	**Paste A:** Di-epoxide, calcium tungstate, zirconium oxide, aerosil, pigment (Iron oxide) **Paste B:** 1-adamantane amine, N,N-dibenzyl-5-oxa-nonandiamine-1,9, TCD-Diamine, calcium tungstate, zirconium oxide, aerosil, silicone oil	Dentsply Maillefer, Ballaigues, Switzerland.	4 hours	8 hours	No	No
Gutta Flow2	Gutta-percha powder, poly-dimethyl siloxane, silicon oil, paraffin oil, platinum catalyst, zirconium dioxide, nano silver	Colten/Whaledent GmbH, Langenau Germany	10-15 min	25-30 min	No	No
BioRoot RCS	**Powder :**Tricalcium silicate, povidone and zirconium oxide **Liquid:** Aqueous solution of calcium chloride and polycarboxylate.	BioRoot RCS; Septodont, Saint Maur Des Fosses, France	15 min	4 hours	Yes	yes

Table 1. Chemical composition and characteristics of the sealers.

Results

Among the sealers tested, BioRoot RCS group exhibited the highest bond strength value. The post hoc Tukey's testrevealed a significant difference between BioRoot RCS and AH Plus group ($p<0.05$). Guttaflow2 revealed a higher bond strength value than AH Plus, however, these two groups did not differ statistically (Table 2).

Sealers (n=10)	Mean value (MPa)	Standard Deviation
AH Plus	19.54*	2.67
GuttaFlow 2	22.88	1.46
BioRoot RCS	37.82*	1.73
Statistically significant difference between the groups is denoted by*.		

Table 2. Mean Push-out Bond Strength values of the three root canal sealers with intergroup comparison between the sealers, $p < 0.05$ (ANOVA and Post hoc Tukey's test).

Discussion

One of the key components of a sealer is its adhesion to the canal wall. Several factors affect the retention of an endodontic sealer, such as its physical and chemical properties, the morphology of the canal and obturation technique.[10-15]

In this study, BioRoot RCS reported the highest values, followed by GuttaFlow2 and AH Plus. The composition of calcium silicate sealers provides for some chemical bonding to the root dentine.[16] The calcium silicate-based sealers release calcium hydroxide on hydration and can lead to the formation of calcium phosphate or calcium carbonate on the interface.[17] They bond to the root dentin by a biochemical process known as bio-mineralisation by forming a crystalline bond.[18] The use of EDTA has been shown to affect the mineral infiltration zone which is responsible for the retention of the calcium silicate sealers to the radicular dentin. Prasanthi et al. showed that the ProRoot MTA samples treated with 17% EDTA exhibited low push-out bond strength.[19] Lee et al. reported that 17% EDTA showed unfavourable effects on hydration of calcium silicate-based sealers.[20] Yan et al. showed that 17% EDTA decreased the bond strength of calcium silicate-based sealers to the root canal wall.[21] The absence of EDTA in the irrigation protocol in this study may be one of the reasons for the high bond strength scores of BioRoot RCS obtained as compared to previous studies.[17,19]

GuttaFlow2 is a further development and successor of the silicone sealer GuttaFlow, exhibiting a stiffer consistency. In the present study it exhibited better results when compared to AH plus. This could be due to its property to undergo an expansion of as much as 0.2 %, which improves the adaptability to the root canal wall.[8]

The results of our study are along the lines with research of previous authors, despite variations in methodologies. According to Turker et al. calcium silicate sealers result in superior adhesion to root dentin compared to epoxy resin based sealers and concluded that the BioRoot RCS showed a higher value compared to AH-26, which supports the findings of our study.[22]

Though data about dislodgement resistance of BioRoot RCS is sparse, a strong bond between various bioceramic sealers and dentin has been documented in the literature. According to Ersahan et al. the bonding of bioceramic sealer, iRoot SP to dentin is comparable to AH plus and was stronger than the EndoRez sealer.[23] According to Shokouhinejad et al. the bond strength of EndoSequence BC was almost equal to that of AH Plus.[24] Bouillaguet et al. studied the apical sealing capacity of different sealers and reported better results from GuttaFlow and Epiphany than with PCS and AH Plus; concluding that the leakage of AH-Plus may have been due to insufficient adherence between AH Plus and the gutta-percha, permitting fluid to penetrate at their interface.[25] Savariz et al. studied the long-term sealing ability of GuttaFlow with regards to various obturation techniques and concluded that GuttaFlow displayed a more sealing ability both apically and coronally than AH Plus over time.[26]

Contrary to our results, Donnermeyer et al. have observed significantly greater bond strength of AH plus sealer than BioRoot RCS and GuttaFlow2.[17] But the variation in the results could be due to the use of EDTA in the irrigation protocol, which as previously stated is known to compromise the bond of the silicate based cements.[19-21]

Due to certain limitations of this study such as the in-vitro conditions, the time duration of the study and lack of failure analysis of the samples, further investigations regarding the aforementioned parameters of the sealers tested in this study can be conducted.

Conclusions

The adherence between the endodontic sealer and the canal wall must be strong and long-lasting in order to preserve the interface between the sealer and the dentin. The sealers must possess dislodgement resistance especially during tooth flexure and the preparation of post space. Hence the current study evaluated the bond strengths of the three endodontic sealers by push-out test design and according to the results of this study BioRoot RCS showed the maximum push out bond strength when used with the lateral condensation technique of obturation with the absence of EDTA.

Declaration of Interest

The authors report no conflict of interest.

References

1. Ordinola-Zapata R, Bramante CM, Graeff MS, et al. Depth and percentage of penetration of endodontic sealers into dentinal tubules after root canal obturation using a lateral compaction technique: a confocal laser scanning microscopy study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;108(3):450-457.
2. El Hachem R, Khalil I, Le Brun G, et al. Dentinal tubule penetration of AH Plus, BC Sealer and a novel tricalcium silicate sealer: a confocal laser scanning microscopy study. Clin oral investig 2019;23(4):1871-6.
3. Neelakantan P, Subbarao C, Subbarao CV, De-Deus G, Zehnder M. The impact of root dentine conditioning on sealing ability and push-out bond strength of an epoxy resin root canal sealer. Int Endod J 2011; 44(6):491-498.
4. Furtsev TV, Kazanovskaya AA, Zeer GM, Zelenkova EG. Evaluation of the effectiveness of root canal obturation depending on the treatment methods. Journal of International Dental and Medical Research 2020;13(1):1-7.
5. Dem K, Wu Y, Kaminga AC, Dai Z, Cao X, Zhu B. The push out bond strength of polydimethylsiloxane endodontic sealers to dentin. BMC oral health 2019;19(1):1-6.
6. Jowkar Z, Omidi Y, Shafiei F. The effect of silver nanoparticles, zinc oxide nanoparticles, and titanium dioxide nanoparticles on the push-out bond strength of fiber posts. J Clin Exp Dent 2020;12(3):e249-e256.
7. Camps J, Jeanneau C, El Ayachi I, Laurent P, About I. Bioactivity of a Calcium Silicate-based Endodontic Cement (BioRoot RCS): Interactions with Human Periodontal Ligament Cells In Vitro J Endod 2015; 41(9):1469-1473.
8. Upadhyay ST, Purayil TP, Ballal NV. Evaluation of push-out bond strength of GuttaFlow 2 to root canal dentin treated with different smear layer removal agents. Saudi Endod J 2018; 8(2):128-132
9. Hergt A, Wiegand A, Hülsmann M, Rödig T. AH Plus root canal sealer–an updated literature. Endod Pract 2015; 9(4):245-65.
10. Donnermeyer D, Dornseifer P, Schäfer E, Dammaschke T. The push-out bond strength of calcium silicate-based endodontic sealers. Head & face med 2018;14(1):1-7.
11. Paulson L, Ballal NV, Bhagat A. Effect of Root Dentin Conditioning on the Pushout Bond Strength of Biodentine. J Endod 2018; 44(7):1186-1190.

12. DeLong C, He J, Woodmansey KF. The effect of obturation technique on the push-out bond strength of calcium silicate sealers. J Endod 2015; 41(3):385-388.
13. Teixeira CS, Alfredo E, Thomé LH, Gariba-Silva R, Silva-Sousa YT, Sousa-Neto MD. Adhesion of an endodontic sealer to dentin and gutta-percha: shear and push-out bond strength measurements and SEM analysis. J Appl Oral Sci 2009; 17(2):129-135.
14. Rahoma A, AlShwaimi E, Majeed A. Push-out bond strength of different types of mineral trioxide aggregate in root dentin. Int J Health Sci (Qassim) 2018; 12(5):66-69.
15. Kaya S, Ozer SY, Yavuz I, Aydin H. Comparison of dye extraction or dye penetration methods to quantitatively determine microleakage of three different root canal sealers. Dentistry 2011;1(02):1-5.
16. Han L, Okiji T. Bioactivity evaluation of three calcium silicate-based endodontic materials. Int Endod J 2013; 46(9):808-814.
17. Donnermeyer D, Vahdat-Pajouh N, Schäfer E, Dammaschke T. Influence of the final irrigation solution on the push-out bond strength of calcium silicate-based, epoxy resin-based and silicone-based endodontic sealers. Odontology 2019; 107(2):231-236.
18. Reyes-Carmona JF, Felippe MS, Felippe WT. The biomineralization ability of mineral trioxide aggregate and Portland cement on dentin enhances the push-out strength. J Endod 2010; 36(2):286-291.
19. Prasanthi P, Garlapati R, Nagesh B, Sujana V, Kiran Naik KM, Yamini B. Effect of 17% ethylenediaminetetraacetic acid and 0.2% chitosan on push-out bond strength of biodentine and ProRoot mineral trioxide aggregate: An in vitro study. J Conserv Dent 2019; 22(4):387-390.
20. Lee YL, Lin FH, Wang WH, Ritchie HH, Lan WH, Lin CP. Effects of EDTA on the hydration mechanism of mineral trioxide aggregate. J Dent Res 2007; 86(6):534-538.
21. Yan P, Peng B, Fan B, Fan M, Bian Z. The effects of sodium hypochlorite (5.25%), Chlorhexidine (2%), and Glyde File Prep on the bond strength of MTA-dentin. J Endod 2006; 32(1):58-60.
22. Aktemur Türker S, Uzunoğlu E, Purali N. Evaluation of dentinal tubule penetration depth and push-out bond strength of AH 26, BioRoot RCS, and MTA Plus root canal sealers in presence or absence of smear layer. J Dent Res Dent Clin Dent Prospects 2018; 12(4):294-298.
23. Ersahan S, Aydin C. Dislocation resistance of iRoot SP, a calcium silicate-based sealer, from radicular dentine. J Endod 2010; 36(12):2000-2002.
24. Shokouhinejad N, Gorjestani H, Nasseh AA, Hoseini A, Mohammadi M, Shamshiri AR. Push-out bond strength of gutta-percha with a new bioceramic sealer in the presence or absence of smear layer. Aust Endod J 2013; 39(3):102-106.
25. Bouillaguet S, Shaw L, Barthelemy J, Krejci I, Wataha JC. Long-term sealing ability of pulp canal sealer, AH-Plus, GuttaFlow and epiphany. Int Endod J 2008; 41(3):219-226.
26. Savariz A, González-Rodríguez MP, Ferrer-Luque CM. Long-term sealing ability of GuttaFlow versus Ah Plus using different obturation techniques. Med Oral Patol Oral Cir Bucal 2010; 15(6):e936-e941.