Evaluation of push-out bond strength of BioRoot RCS and AH Plus after using different irrigants: An *in vitro* study

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**Abstract**

**Aim:** The aim of this study was to compare push-out bond strength of root canal spaces filled with AH-Plus and BioRoot RCS after using different irrigants.

**Materials and Methods:** Eighty single-rooted teeth were decoronated and endodontically treated by crown-down technique using ProTaper Universal rotary files progressively till F4 (40/0.06). Samples were divided into two groups according to the sealer (n = 40): Group A = BioRoot RCS, Group B = AH Plus, further subdivided into four subgroups according to irrigation protocol (n = 10): Group 1A, 1B – 0.9% saline, Group 2A, 2B – 5.25% NaOCl + 17% EDTA, Group 3A, 3B– 17% EDTA +2% chlorhexidine, and Group 4A, 4B – 17% EDTA + 3% green tea extract. Samples were obturated with sealers and prepared for push-out test with root slices of 2 mm thickness using universal testing machine. Data were statistically analyzed using two-way ANOVA, Bonferroni’s post hoc analysis, and independent Student’s *t*-test.

**Results:** BioRoot RCS exhibited significantly higher push-out bond strength (*p* < 0.001). The interaction between irrigants and sealer showed higher bond strength for BioRoot RCS when 17% EDTA + green tea was used.

**Conclusion:** Within the limitation of the study, it was concluded that bond strength of a sealer was influenced by the irrigants used.

**Keywords:** AH Plus; BioRoot RCS; green tea; push-out bond strength

**INTRODUCTION**

The success of endodontic treatment depends on debridement, elimination of pathogenic organism, and complete sealing of the root canals preventing the entry of bacteria from the oral environment and spreading it to the periapical tissues.[1] Mechanical instrumentation along with proper disinfecting solutions and use of intracanal medicaments considerably reduces the microbial loads within the infected canals.[2] However, microcomputed tomography scans before and after instrumentation show that 35% or more of the root canal surfaces (including canal fins, isthmi, and cul-de-sacs) remain uninstrumented reinforcing the fact that irrigation is an essential part of root canal debridement.[3] Irrigants used during chemomechanical preparation act as the antimicrobial agent, flush out loose debris, and dissolve the organic and inorganic component of smear layer enabling better adaption between sealer and dentinal walls.[4,5]

The hermetic seal between the canal wall and core filling material is achieved by sealer which is critical for preventing...
root canal infection due to regrowth of microorganism or newly gained infection by apical or coronal leakage. The bacterial tight seal achieved by endodontic sealer is therefore a major aspect for assessing the properties of various endodontic sealer.[6]

AH Plus is an epoxy resin-based sealer used frequently as a reference material because of reduced solubility, long-term dimensional stability, and greater retention to root dentin.[3]

BioRoot RCS is a recently launched hydraulic tricalcium silicate-based sealer containing tricalcium silicate, zirconium oxide, etc. Due to prolonged release of Ca+ ions after setting and alkalinity of the sealer, it possesses high antimicrobial and low cytotoxic property promoting endodontic and periodontal regeneration. It has gained popularity because of its ability to seal in presences of hydrophilic atmosphere by mineralization and apatite deposition at canal wall interface.[7]

Push-out bond strength is considered as relevant prognostic factor for evaluation of the link between sealer to the canal wall and the core material measuring interfacial shear bond strength between root dentin and intracanal filling material by calculating the load required to dislodge the filling material.[8] High bond strength to dentin is considered as an important property of the sealer since it contributes to gap-free interface between dentin and root canal filling material which is crucial for establishing fluid tight seal and providing resistance for dislocation of the root filling during tooth flexure and operative procedure.[9]

Therefore, the purpose of this study was to compare the push-out bond strength of root canal space filled with AH Plus and BioRoot RCS after using different irrigants.

**MATERIALS AND METHODS**

**Sealers used in the present study**

1. BioRoot RCS (Septodont, Saint-Maur-des-Fosses, France)
2. AH Plus (DENTSPLY Maillefer, Tulsa, OK, USA).

**Preparation of the green tea extract dilutions**

Green tea extract was supplied by Cymbio Pharma Pvt. Ltd, Yelahanka, Bangalore, India. It was extracted with warm water. Aqueous extracts were then filtered, concentrated, and extracted twice with organic solvent and then dissolved, filtered, and air-dried under vacuum to obtain powder. Nine grams of green tea extract was then diluted in 91 ml of distilled water to get 3% polyphenols.

**Sample preparation**

Eighty single-rooted human permanent teeth extracted for orthodontic or periodontal reason were collected. Teeth with mature apex, patent canals, without any anatomical variations were included in the study whereas teeth with open apex, calcified canal, dilacerated roots, multirooted teeth, carious, restored and fractured tooth were discarded from the study.

Extracted teeth were decoronated to provide 16 mm ± 1 of root with diamond disc underwater coolant system. Canal diameter was standardized with apical file #25 (Mani). The working length was determined by letting the tip of K-file size 10 to be just visible through the apical foramen, and the length obtained was recorded as the working length after subtracting 1 mm. Instrumentation was completed using ProTaper Universal rotary files (DENTSPLY) in crown-down manner till F4 (40/0.06). Between each instrument, canals were irrigated with 2 ml 5.25% NaOCl solution except for group irrigated with saline.

Samples were randomly divided into two groups (n = 40) according to the endodontic sealer used:

- Group A: Obturation with BioRoot RCS + gutta-percha
- Group B: Obturation with AH Plus + gutta-percha.

Each group were further subdivided into four subgroups (n = 10) depending on final irrigation regime [Table 1 and Figure 1].

In total, 5 ml of each irrigating solution was applied for 1 min using 30G side-vented needle (NaviTip). 5 ml saline was used intermittently and as a final flush to remove any remnant of the irrigating solution and dried using #40 paper points.

Group A was filled with BioRoot RCS + gutta-percha, whereas Group B was filled with AH Plus + gutta-percha. For both materials, sealer was coated with Lentulo spiral along the walls of the canal and obturated with #40/0.06 up to working length using cold lateral condensation technique. Additional cones were used to complete obturation and then were allowed to set for 1 week before push-out assessment.

Roots were then sectioned horizontally using a diamond disc into approximately 2 mm thick slices measured using digital caliper. Three sections were cut at 3, 7, and 11 mm representing mid-apical, mid-middle, and mid-coronal root canal levels, respectively [Figure 2].

**Table 1: Experimental groups**

| Groups          | Final irrigation protocol                        |
|-----------------|--------------------------------------------------|
| SubGroup A1/B1  | Saline                                           |
| SubGroup A2/B2  | 5.25% NaOCl + 17% EDTA                          |
| SubGroup A3/B3  | 17% EDTA + 2% Chlorhexidine                      |
| SubGroup A4/B4  | 17% EDTA + 3% Polyphenol Green Tea Extract       |

EDTA: Ethylenediaminetetraacetic acid
Push-out bond strength test

The root slices were mounted on custom-made acrylic mold with cavity in the middle to facilitate push-out of filling material. Compressive loading was performed apico-coronally by means of universal testing machine using cylindrical stainless-steel plunger 0.6 mm (coronal) and 0.4 mm (apical and middle) at a crosshead speed of 2 mm/min until debonding occurred. The plunger was placed in such a way that it covered maximum filling material without touching the canal wall.

Bond strength was determined using computer software program plotting load/time curve during compression testing. Failure was noted when a sharp decline was observed on the graph and/or complete dislodgment of root filling material. The maximum failure load was recorded in NEWTONS (N) and converted into MEGAPASCALS (MPa). The bond strength was calculated using the recorded peak load divided by the computed surface area that was obtained by the following formula:

\[
\text{Bond} = \frac{F}{A} \quad (F = \text{Force}, \ A = \text{Area})
\]

\[
A = \pi h \left( r_1 + r_2 \right)
\]

\[\Pi = \text{Constant} \times 3.14\]

\[r_1 = \text{apical radius}\]

\[r_2 = \text{coronal radius}\]

\[h = \text{Thickness of the sample in millimeters}\]

Data obtained were subjected to statistical analysis using two-way ANOVA, followed by Bonferroni’s post hoc Analysis and Student’s t-test.

RESULTS

Statistical analysis of mean push-out bond strength showed no statistically significant difference at level of sections (i.e., coronal, middle, and apical) within each group. Hence, values for all thirds within one group were combined to increase the power of the statistical test.

DISCUSSION

The success of endodontic treatment depends on various factors such as chemomechanical preparation, obturation, and ultimately postendodontic restoration. The main goal of this treatment is to eliminate microbial entity and prevent future occurrence of re-infection by achieving hermetic seal." Gutta-percha is a biocompatible material to fill radicular space whereas sealer is essential to aggregate the filling material, maintain compact mass without voids, adhere it to the canal wall, and provide single unit configuration.

Push-out tests have been widely used to evaluate dislodgement resistances of root canal filling material. 2 mm thick slices were preferred to prevent premature debonding and sealer detachment while slicing, which was
accordance to Pane et al.[11] The pin, relatively close to 90% of the canal diameter, was selected for each slice, i.e., 0.6 mm for coronal and 0.4 mm for middle and apical third. Visual inspection was done to ensure vertical angulation of the tooth embedded in resin, and any tooth that seemed slightly deviated away from the vertical was removed.[12]

In the current study, 17% EDTA was used for 1 min for all irrigation groups; otherwise, it may cause demineralization and in advert erosion of dentin, thereby reducing modulus of elasticity and flexure strength of dentin which might severely affect the properties of dentin and ultimately increase the chances of root fracture.[9,13]

Cold lateral condensation technique was selected for the current study as recommended by the manufacturers of the BioRoot RCS. Further, the properties of sealers are affected by heat application during warm vertical compaction for both BioRoot RCS (Camilleri 2015), which showed reduced flow and setting time, and AH Plus, which revealed an increase in film thickness with premature aging and decrease in setting time and strength.[7,14,15]

Samples irrigated with 17% EDTA + green tea extracts showed the highest bond strength. Green tea extract is well known for its powerful antioxidant property and consists of major polyphenols, epigallocatechin-3-gallate (EGCG), a collagen cross-linking agent. Furthermore, it has a chelating ability. Hence, the probable reason for the highest bond strength with 17% EDTA + green tea could be collagen stabilization and chelating ability by EGCG.[16]

According to Bayram et al., removal of smear layer from the canal wall allows penetration of sealer into the dentinal tubules, thereby increasing adhesion to the root canal dentin. In the current study, smear layer was not removed from dentinal wall when irrigated with saline. Hence, both sealers exhibited lower bond strength since sealers was not able to penetrate the dentinal tubules.[17]
Subsequent to green tea better result was seen with 5.25% NaOCl + 17% EDTA, followed by 17% EDTA + 2% chlorhexidine (CHX) in BioRoot RCS. The possible explanation for this could be the alternating usage NaOCl, and EDTA dissolves the organic component of the dentin and demineralizes the inorganic constituent which leads to absences of smear layer and smear plugs allowing bioceramic sealers to penetrate the dentinal tubules and increases mechanical retention and bond strength of sealer to root dentin.\[^{[19]}\]

In subgroup A2 and B2, 17% EDTA was used as final rinse since it demineralizes peritubular dentin during the initial stages of irrigation, and after usage of NaOCl, it might dissolve exposed organic matrix.\[^{[19]}\]

When samples were irrigated with 17% EDTA + 2% CHX, CHX was used as the final rinse since it does not cause erosion of dentin unlike NaOCl.\[^{[20]}\] Therefore, 2% CHX was considered for irrigation after smear layer removal. Studies suggested that the presence of surface surfactant in 2% CHX increases the dentin surface energy, wettability, and reaction of polycarboxylic group enhancing the cationic charge. This property is required for the adhesion of bioceramic sealers due to its hydrophilic nature. Hence, it could be the possible reason for better bond strength of BioRoot RCS when compared to AH Plus when 2% CHX was used as a final irrigant.\[^{[9]}\]

According to the results of the present study, BioRoot RCS showed better bond strength to root dentin compared to AH Plus probably due to setting reaction of the bioceramic-based sealer. It absorbs water from the dentinal tubules and forms calcium silicate hydrogel and hydroxyapatite compound. The calcium silicate hydrogel chemically binds to the hydroxyapatite via the hydroxyl group. The hydroxyapatite present in the sealer undergoes a continuous process of crystal growth and binds chemically with the dentin. Furthermore, by being resin free, they are capable of flowing into the dentinal tubules with no shrinkage.\[^{[15,16]}\] It provides excellent adhesion to dentin and gutta-percha and its ability to seal auxiliary canals, owing to its high flowability and hydrophilic behavior, allows continuous sealing in the presence of moisture.\[^{[21]}\] The interaction of this with tissue fluids results in the formation of mineral tags.\[^{[22]}\]

Under the limitations of this in vitro study, the results obtained have to be re-confirmed with further research.

### CONCLUSION

Within the limitation of this study:
- BioRoot RCS showed significantly higher bond strength compared to AH Plus
- 17% EDTA + green tea fostered significantly higher bond strength when dentin surface treatment is taken into consideration
- When irrigant, sealer effect, and their interactions were analyzed, significantly higher bond strength was observed with BioRoot RCS when 17% EDTA + green tea was used as an irrigant.

Hence, irrigation protocols influenced the push-out bond strength of the bioceramic-based BioRoot RCS and resin-based AH Plus sealer.

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### Conflicts of interest

There are no conflicts of interest.
REFERENCES

1. Verma D, Taneja S, Kumari M. Efficacy of different irrigation regimes on the push-out bond strength of various resin-based sealers at different root levels: An in vitro study. J Conserv Dent 2018;21:125-9.
2. Razmi H, Bolhari B, Karamzadeh Dashht N, Fazlyab M. The effect of canal dryness on bond strength of bioceramic and epoxy-resin sealers after irrigation with sodium hypochlorite or chlorhexidine. Iran Endod J 2016;11:129-33.
3. Agrawal Vineet S, Rajesh M, Sonali K, Mukesh P. A contemporary overview of endodontic irrigants-a review. J Dent App 2014;1:105-15.
4. Farag HA, Eltman WM, Alhadainy HA, Darrag AM. Effect of different irrigating protocols on push out bond strength of Resilon/Epiphany obturation system. Tanta Dent J 2015;12:241-8.
5. Vilanova WV, Carvalho-Junior JR, Alfredo E, Sousa-Neto MD, Silva-Sousa YT. Effect of intracanal irrigants on the bond strength of epoxy resin-based and methacrylate resin-based sealers to root canal walls. Int Endod J 2012;45:42-8.
6. Tyagi S, Mishra P, Tyagi P. Evolution of root canal sealers: An insight story. Europ J General Dent 2013;2:199.
7. Viapiana R, Moinzadeh AT, Camilleri L, Wesselink PR, Tanomaru Filho M, Camilleri J. Porosity and sealing ability of root fillings with gutta-percha and BioRoot RCS or AH Plus sealers. Evaluation by three ex vivo methods. Int Endod J 2016;49:774-82.
8. Madhuri GV, Varri S, Bolla N, Mandava P, Akkala LS, Shaik J. Comparison of bond strength of different endodontic sealers to root dentin: An in vitro push-out test. J Conserv Dent 2016;19:461-4.
9. Tuncel B, Nagas E, Cehreli Z, Uyanik O, Vallittu P, Lassila L. Effect of endodontic chelating solutions on the bond strength of endodontic sealers. Brazilian Oral Research 2015;29:1-6.
10. 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;17:129-39.
11. Pane ES, Palamara JE, Messer HH. Critical evaluation of the push-out test for root canal filling materials. J Endod 2013;39:669-73.
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;41:385-8.
13. Shivanna V. The effect of different irrigating solutions on the push-out bond strength of endodontic sealer to dentin and assessing the fracture modes: An In-vitro study. J Int Clin Dent Res Organ 2014;6:86.
14. Simon S, Flouriot AC. BioRoot TM. RCS a new biomaterial for root canal filling. J Case Studies Collection 2016;13:4-11.
15. BioRoot RCS Brochure Website: Available from: http://www.oraverse.com/bioimg/BioRoot-ScientificFile.pdf. [Last accessed on 2020 Apr 26].
16. Pheenithicharoenkul S, Panichuttra A. Epigallocatechin-3-gallate increased the push out bond strength of an epoxy resin sealer to root dentin. Dent Mater J 2016;35:888-92.
17. Bayram HM, Bayram E, Kanber M, Celikten B, Saklar F. Effect of different chelating solutions on the push-out bond strength of various root canal sealers. Biomed Res 2017;S401-6.
18. Ibrahim NK, Nayif MM. Bond strength of Endosequence Bioceramic sealer to root canal dentine irrigated with different solutions. Int J Enhanc Res Sci Tech Eng 2015;4:136-9.
19. Moon YM, Shon WJ, Baek SH, Bae KS, Kum KY, Lee W. Effect of final irrigation regimen on sealer penetration in curved root canals. J Endod 2010;36:732-6.
20. Haapasalo M, Shen Y, Wang Z, Gao Y. Irrigation in endodontics. Br Dent J 2014;216:299-303.
21. Hamdan R, Michetti J, Dionnet C, Diemer F, Georgelin-Gurgel M. In-vitro evaluation of apical microleakage of two obturation methods of immature permanent teeth: Orthograde apical plug of Mineral Trioxide Aggregate and root canal filling combining custom gutta-percha cone with Calcium Silicate-based sealer. Giornale Italiano di Endodoncia 2017;31:89-95.
22. Xuereb M, Vella P, Damidot D, Sammut CV, Camilleri J. In situ assessment of the setting of tricalcium silicate-based sealers using a dentin pressure model. J Endod 2019;41:111-24.