Influence of 2% chlorhexidine on the dislodgement resistance of AH plus, bioroot RCS, and GuttaFlow 2 sealer to dentin and sealer-dentin interface

Debosmita Roy, Rubi Kataki, Lima Das, Khushboo Jain
Department of Conservative Dentistry and Endodontics, Regional Dental College, Guwahati, Assam, India

Abstract

Aim: To find out the effects of 2% chlorhexidine (CHX) gel intracanal medicament on the dislodgement resistance of AH Plus, BioRoot RCS, and GuttaFlow 2 Sealer to dentin and on sealer-dentin interface.

Materials and Methods: Sixty single-rooted maxillary canine were taken and divided into two groups based on the treatment: Group 1 – control group (no medicament) \( n = 30 \) and Group 2 – (GLUCO-CHeX 2% Gel) \( n = 30 \). Further, the groups were divided according to the sealer used, namely (A) AH Plus sealer, (B) BioRoot RCS Sealer, and (c) Gutta Flow 2 sealer. Teeth were prepared using rotary instrumentation of file size 35 with a taper of 0.06 and obturation was done. 1 mm thick sections were obtained from the roots. All the sections were checked for push out bond strength using Universal testing machine and mode of failure using stereomicroscope. Some samples were evaluated for sealer-dentin interface using field emission scanning electron microscope.

Results: AH Plus showed higher bond strength compared to BioRoot RCS and GuttaFlow 2. There was no significant difference in the push out bond strength with or without the prior use of 2% CHX medicament \( (P > 0.05) \) and also CHX did not affect the mode of failure. However, sealer-dentin interface gap was increased with application of medicament.

Conclusion: Dislodgement resistance of AH Plus sealer is significantly higher than BioRoot RCS and GuttaFlow 2 sealer. The application of 2% CHX intracanal medicament before root canal obturation did not significantly affect the dislodgement resistance of the three tested sealers. 2% CHX medicament did not affect the failure mode of the sealers. Sealer-dentin interface is affected by the use of 2% CHX gel medicament.

Keywords: AH Plus; BioRoot RCS; chlorhexidine; dislodgement resistance; microscopy; silicone sealers

INTRODUCTION

Endodontic evolution regarding the different techniques of obturation and different sealers is a continuous process. Various factors during the endodontic treatment can interfere with the adhesion of the root canal sealers to the canal wall such as the presence or absence of smear layer, dentin moisture conditions, different irrigation protocols, irradiation, intracanal medicaments, a wide variety of obturation techniques, use of various solvents in retreatment cases, various dentin drying protocols resulting in increased or decreased bond strength.[1-3]

Studies have revealed that chlorhexidine (CHX) gluconate effectively decontaminates the root canal system,[4] did not adversely affect the sealing ability of root canal cements,[5-7] and increased the bond strength to dentin.[1,3,8-10] The aim of the present study was to find out the effects of 2% CHX gel intracanal medicament on the dislodgement resistance...
of three different root canal sealers - AH Plus, BioRoot RCS, and GuttaFlow 2 sealer to dentin and its effect on sealer-dentin interface. Followings are the null hypothesis put forward: (i) there is no significant difference in the push-out bond strength (POBS) of the sealers (AH Plus, BioRoot RCS, and GuttaFlow 2) with or without the use of prior 2% CHX intracanal medicament and (ii) the use of intracanal medicament (2% CHX) has no effect on the sealer-dentin interface.

MATERIALS AND METHODS

The study followed the MODIFIED CONSORT guidelines for in vitro studies. Prior to conducting the study, ethical clearance was obtained from the institutional ethical committee board. A sample size of 60 teeth was determined for the study using the formula, \( n = \left( \frac{Z_{\alpha/2} \times s}{E} \right)^2 \). Where \( Z_{\alpha/2} = 1.96 \) (at 95% confidence level), \( s \) is the estimated population standard deviation (estimated from previous studies) and \( E \) is the desired error of the estimated population mean. Noncarious, single-rooted teeth with closed apices, with an approximate root length of at least 16 mm, were chosen. Teeth with root caries, anatomical deformities, immature teeth, teeth with more than one canal, cracked or fractured teeth, teeth with previous endodontic treatment and restorations, were excluded. The samples were verified radiographically and clinically to access a single root canal. The samples were randomly divided into two groups as follows: Group 1: Control Group \( (n = 30) \): without any intracanal medicament. Group 2: Experimental Group \( (n = 30) \): teeth treated with 2% CHX gel intracanal medicament.

Root canal preparation

Conventional access cavities were prepared using an Endo-access Bur (DENTSPLY Mallifer, Switzerland) and No. 10 and No. 15 K files (DENTSPLY M access, Maillefer Instruments Holding Sarl, Switzerland) were used to negotiate the canal and measure the working length, which was kept 0.5 mm short of the apical foramen. The root canals were serially enlarged up to a size of 35 with a taper of 0.06 using Neo Endo Flex Rotary File System (Orikam Healthcare India Pvt Ltd, Gurugram, Haryana, India). The instruments were moved in the apical direction using an in-and-out pecking motion. Canals were irrigated with 3% NaOCl, 17% ethylenediaminetetraacetic acid (EDTA) and saline between each preparation step. At the end of preparation, saline was used as the final rinse. The control group (Group 1) did not receive intracanal medicament. The experimental group (Group 2) was treated with 2% CHX gel (GLUCO - CHeX 2% Gel) (CERKAMED, Kwiatkowskiego, Stalowa Wola, Poland) using lentulospiral (DENTSPLY, Maillefer, Switzerland). The access cavity was sealed with temporary restorative material (Cavit G, 3M Deutschland GmbH, 3M ESPE, Germany) and the samples were stored at 37°C and 100% relative humidity for 2 weeks. The medicament was removed from the samples by manual use of files and irrigation using 5 mL of 3% NaOCl, 5 mL of 17% EDTA, and a final flush was done using 5 mL saline. Subsequently, both the groups were divided based on the sealer used for obturation. All the groups were obturated with single-cone obturation technique.

- Group A: AH Plus sealer (DENTSPLY, DeTreyGmbH, Konstanz, Germany) \( (n = 10) \)
- Group B: BioRoot RCS (Septodont, St Maur-des-Fosses, France) \( (n = 10) \)
- Group C: GuttaFlow 2 (Coltène/Whaledent, Langenau, Germany) \( (n = 10) \).

All the sealers were manipulated according to the manufacturer’s instruction. All the samples were stored at 37°C and 100% relative humidity for 2 weeks.

Dislodgement resistance using push-out bond strength test

Each root was sectioned at coronal, middle and apical root thirds, perpendicularly to its axis into 1 mm thick serial slices using a Linear Precision Saw (ISOMET 4000, Buehler, Germany). The first three slices obtained from each root were used for the POBS test in a Universal Testing Machine (INSTRON-Dynamic UTM). Long shafts with tip diameters of 0.3, 0.5, and 1 mm were used for testing the apical third, middle third, and coronal third, respectively. The apical surface was placed facing the punch tip, ensuring that loading forces were introduced from an apical to the coronal direction. A constant load at 1 mm/min was applied until the dislodgement of the filling material. POBS data in Mega Pascal were collected from the computer attached to the machine. Mode of Failure: Few samples that were tested for POBS from each group were viewed under the Stereomicroscope (Nikon SMZ25, Nikon, USA) at \( \times 40 \) magnification to see the mode of failure. The failure modes were classified as - (a) adhesive-between the sealer and dentin of root canal wall, (b) cohesive-within the sealer itself, and (c) mixed. Sealer-Dentin Interface: Few sections from each group were used for qualitative analysis of sealer-dentin interface by field emission scanning electron microscope (Sigma300) at \( \times 15,000 \) magnification.

Statistical analysis

The data of the present study were statistically analyzed at a 0.05 significance level. Intergroup overall comparison of control and experimental groups and with respect to comparison of the root thirds – coronal, middle, and apical third and to Sealer Type was done using Mann–Whitney U-tests. All the statistics have been calculated and computed using Statistical Package for Social Sciences (SPSS) version 20 (IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp) and all diagrams have been prepared using Microsoft Excel 2007.
RESULTS

Dislodgement resistance
A total of 60 teeth were evaluated in the study. The results showed that AH Plus sealer had higher bond strength compared to BioRoot RCS and GuttaFlow 2 sealer and the application of 2% CHX gel intracanal medicament did not significantly affect the dislodgement resistance of the three tested sealers \((P > 0.05)\) [Table 1]. With regard to the AH Plus sealer, in the coronal and middle third sections, bond strength seemed to decrease after application of medicament, whereas for the BioRoot RCS only coronal third bond strength decreased \(\text{[Table 2]}\). The adhesion of GuttaFlow 2 sealer to dentin is weak and so the bond strength values were less \(\text{[Table 2]}\). Furthermore, it was found that apical sections had higher bond strength values than middle third and coronal third sections for all the groups.

Stereomicroscopic analysis
Stereomicroscopic analysis revealed that AH Plus and BioRoot RCS sealer had a cohesive mode of failure both in the control group and in the Experimental groups. Whereas GuttaFlow 2 Sealer had mixed failure mode in the control group, whereas in the experimental group, it had both mixed and adhesive type of failure \(\text{[Figure 1]}\).

Sealer-dentin interface
Qualitative SEM analysis revealed a little gap in the AH Plus control group which is less than the gaps present in the BioRoot RCS and GuttaFlow 2 sealer. An increase in the interfacial gap was found in all the sealers (AH Plus, BioRoot RCS, GuttaFlow 2 Sealer) in the experimental group \(\text{[Group 2]}\) [Figure 2].

DISCUSSION

Intracanal medication helps in reducing the microbial load from the root canal system. 2% CHX is the choice of intracanal medicament in persistent endodontic infection.\(^1\) It does not induce alterations in the morphological structure of the dentin organic matrix and thus helps in maintaining the quality of the dentin substrate.\(^2\)

Adhesion of sealers to dentin and to the core material is a complex process with a separate different mechanism for various types of sealers and different conditions of dentin. The bond strength to dentin (or dislodgement resistance) of endodontic sealer is a measure of its adhesive capacity.\(^3\) A strong adhesive interface between the sealer and radicular dentin and the sealer and the core material will prevent microleakage and thus improve the success of endodontic therapy.\(^4\) In this study, the POBS was used to check the dislodgement resistance of three different sealers to dentin with and without the use of prior 2% CHX intracanal medicament. Various tests are employed for measuring bond strength such as shear bond strength, microtensile, and push-out tests. There is no consensus among researchers regarding standardized adhesion tests. Orstavik et al. recommended the use of a UTM to determine the adhesion of root canal sealers.\(^5\) The use of a UTM to

### Table 1: Comparison of mean push out strength between control and experimental groups overall and with respect to root thirds

| Groups | AH Plus | BioRoot RCS | GuttaFlow 2 |
|--------|---------|-------------|-------------|
| Overall | 164±174.9 | 88.9±75.5 | 73±90 |
| Control | 164±174.9 | 88.9±75.5 | 73±90 |
| Experimental | 84.7±69 | 93.1±83.8 | 73.9±77.1 |
| Coronal | 164±174.9 | 88.9±75.5 | 73±90 |
| Control | 84.7±69 | 93.1±83.8 | 73.9±77.1 |
| Experimental | 45±24.1 | 39±16.9 | 5±2.5 |
| Middle | 45±24.1 | 39±16.9 | 5±2.5 |
| Control | 29.6±6.9 | 15.7±4.7 | 14.3±1.4 |
| Experimental | 29.6±6.9 | 15.7±4.7 | 14.3±1.4 |
| Apical | 29.6±6.9 | 15.7±4.7 | 14.3±1.4 |
| Control | 364.5±173.7 | 179.6±61.3 | 181.8±76.5 |
| Experimental | 364.5±173.7 | 179.6±61.3 | 181.8±76.5 |
| NS: Nonsignificant, SD: Standard deviation

### Table 2: Comparison of mean push out strength between control and experimental groups overall and with respect to root thirds

| Groups | AH Plus | BioRoot RCS | GuttaFlow 2 |
|--------|---------|-------------|-------------|
| Overall | 108.6±126.7 | 108.6±126.7 | 108.6±126.7 |
| Control | 108.6±126.7 | 108.6±126.7 | 108.6±126.7 |
| Experimental | 83.9±76.4 | 83.9±76.4 | 83.9±76.4 |
| coronal | 108.6±126.7 | 108.6±126.7 | 108.6±126.7 |
| Control | 108.6±126.7 | 108.6±126.7 | 108.6±126.7 |
| Experimental | 83.9±76.4 | 83.9±76.4 | 83.9±76.4 |
| Middle | 108.6±126.7 | 108.6±126.7 | 108.6±126.7 |
| Control | 108.6±126.7 | 108.6±126.7 | 108.6±126.7 |
| Experimental | 83.9±76.4 | 83.9±76.4 | 83.9±76.4 |
| Apical | 108.6±126.7 | 108.6±126.7 | 108.6±126.7 |
| Control | 108.6±126.7 | 108.6±126.7 | 108.6±126.7 |
| Experimental | 83.9±76.4 | 83.9±76.4 | 83.9±76.4 |
| NS: Nonsignificant, SD: Standard deviation
determine the adhesion of root canal sealers has gained popularity for determining the bond strength with more accuracy and reliability.\[16,17\] Hence, its results can be useful for determining the interfacial strength and dislocation resistance between different root filling materials and the root dentin. The most crucial step of the experimental setup is the ratio of the pin diameter and the specimen’s diameter. A ratio of <0.6\[18\] and ratios higher than 0.85 have been reported to influence the POBS test.\[19\] In the present study, the pin diameter was designed to be within a range of 75%–85% of the gutta-percha cone diameter. The force is applied in apicocoronal direction to avoid interference due to canal taper, during dislodgement of the filling material.\[20\]

The different sealer types are poorly comparable due to their differing hardness when used without a standard core material, and thus the use of core material is to be regarded as a constant.\[21\]

In the present study, when the overall mean push-out strength of the control group and experimental group was compared, there was no statistically significant difference ($P > 0.05$). Furthermore, when a comparison between the POBS of the control group and the experimental group was done based on the root thirds, there was no statistically significant difference. Therefore, the first null hypothesis is accepted. These results are in conjunction with the study done by Neelakantan et al., where they have reported that dentin conditioning with 2% CHX gel did not affect the POBS of the AH Plus sealer.\[7\] The POBS values were found to be greater in the apical than the middle and coronal portion of the root area in both the experimental and control groups. The higher bond strengths in the middle and apical specimens could be related to deeper sealer penetration or because the apical level has marked variations in the structure, including irregular secondary dentin (even cementum like tissue), accessory root canals, and areas of resorption or repaired resorption.\[22,23\] Greater bond strength has been found in apical sections.

In the present study, with regard to AH Plus sealer, there is no statistically significant difference between the mean

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**Figure 1:** Stereomicroscopic images of failure mode analysis: Cohesive failure in Group 1A and Group 1B, Mixed failure in Group 1C, Cohesive failure in experimental Group 2A and Group 2B, Adhesive Failure and Mixed Failure in experimental Group 2C

**Figure 2:** Scanning electron microscopic images: minimal gap containing regions at sealer-dentin interface in control Groups 1A and 1B, increased gap containing regions at sealer-dentin interface in control Group 1C, increased gap containing regions at sealer-dentin interface in experimental Groups 2A-C. D: Dentin, F: Filling
POBS of Groups 1A and 2A, but a significant difference was found in the coronal and middle third as the push-out bond decreased after the application of intracanal medicament in the coronal and middle third. This may be due to residual medicament present which may hinder the penetration of the sealer into the dentinal tubules. With respect to BioRoot RCS; Group 1B and 2B; the bond strength was found to be comparable and only a significant difference was found only in the coronal third. It has been suggested that the presence of surface surfactant in 2% CHX increases the dentin surface energy, wettability, and reaction of the polycarboxylic group enhancing the cationic charge.[24] This property is required for the adhesion of bioceramic sealers due to their hydrophilic nature. Hence, this might be the reason for similar bond strength in the BioRoot RCS control and experimental groups. With respect to GuttaFlow 2 sealer, there was no statistically significant difference between the control and the experimental groups (Group 1C and 2C) but a statistically significant difference in the coronal third was found. Data regarding the interaction of CHX and silicone sealers are sparse. In the study done by David Donnerrmeyer et al.,[2] they have reported no chemical and only minor mechanical interaction between silicone sealers and root canal dentin. In the present study, there was found to be no effect of the 2% CHX medicament on the bond strength of GuttaFlow 2 sealer which means that CHX did not play any part in the bonding of silicone sealer to dentin.

The differences between the sealers were confirmed by the failure mode analysis after the push-out test. Cohesive failure was seen in the AH Plus and BioRoot RCS Group whereas mixed failure in the GuttaFlow 2 group. The application of 2% CHX intracanal medicament had no significant effect on the failure mode of the sealers, as cohesive failure mode was predominant in case of AH Plus and BioRoot RCS whereas both adhesive and mixed type of failure was present in the GuttaFlow 2 sealer in the experimental group. Studies have reported that final irrigation affects the mode of failure.[3] It has been reported that a final flush with EDTA or NaOCl seems to affect the root dentin surface, but in the present study, the final flush was done using NaCl (Saline) which did not modify the root dentin surface thereby having a cohesive mode of failure in both AH Plus and BioRoot RCS group. With respect to GuttaFlow 2 sealer, there is no chemical interaction or adhesion to dentin. Hence, mixed and adhesive type of failure was predominant.

Qualitative SEM analysis revealed a little gap in the AH Plus control group which is less than the gaps present in the BioRoot RCS and GuttaFlow 2 sealer, which corresponds to the results that AH Plus had higher bond strength than BioRoot RCS and GuttaFlow 2 sealer. An increase in the interfacial gap was found in all the experimental Groups which suggests that the application of 2% CHX has affected the sealer-dentin interface of AH Plus, BioRoot RCS and GuttaFlow 2 sealers. Thus, the second null hypothesis is rejected. In a study done by Kontakiotis et al., when using 2% CHX gel intracanal medicament for 2 weeks, large amounts of gel remnants were found in all the apical thirds and reported that removal of 2%CHX gel is difficult than removing calcium hydroxide or calcium hydroxide plus 2% CHX gel.[4] This may be the reason for the increase in the gap of the sealer-dentin interface. The removal technique of intracanal medicament is an important aspect. In this study, manual use of the file, and irrigation using 5 mL 3% NaOCl, 5 ml of 17% EDTA, followed by a final flush of 5 mL saline was used. Due to the unavailability of other aids such as ultrasonic or sonic irrigation, only manual irrigation have been used which might be the reason for the remnants of the medicament.

In the present study, although bond strength was not affected but the sealer-dentin interface was affected by the application of 2% CHX. The limitations of the study were the small sample size and the in vitro nature of the study and clinically relevant conditions such as moisture conditions of the root canals, the effect of different drying conditions were not being taken into consideration. In light of the current study’s results, further research work is warranted.

**CONCLUSION**

Within the limitation of the study, it is concluded that

(i) Application of 2% CHX intracanal medicament prior to root canal obturation did not significantly affect the dislodgement resistance of the three tested sealers-AH Plus, BioRoot RCS and GuttaFlow 2 sealer although some little effect have been found in coronal third for all types of sealers

(ii) Apical segment of each group demonstrated higher bond strength values than the middle and coronal segment

(iii) 2% CHX medicament did not have any effect on the failure mode of the sealers during the tests

(iv) Sealer-dentin interface is affected by the use of 2% CHX gel medicament.

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**Conflicts of interest**

There are no conflicts of interest.

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