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Original Research Article

Effect of Ultrasonic Activation of a Bioceramic Sealer on Its Radicular Push out Bond Strength- an in Vitro Study

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ABSTRACT

Background: Adherence of root canal sealer to root dentin is an important requirement as there is a direct relationship between the bond strength and sealing ability of a sealer. Ultrasonics has been widely used for irrigation and instrumentation purposes but its use for sealer activation has not been explored sufficiently.
Aim: To evaluate the effect of ultrasonic activation of bioceramic root canal sealer on its push-out bond strength to root canal dentine.
Methodology: The root canals of 80 roots of mandibular premolars were prepared with Ni-Ti rotary instruments under irrigation with 5% NaOCl and 17% EDTA. Samples were divided into two groups depending upon the mode of activation of sealer: Ultrasonic Activation (UA) and no activation (NA). Endosequence BC sealer was placed into the canals. In UA group, ultrasonic activation of the sealer was performed for one minute and canals were obturated. In group NA, no activation was performed and samples were obturated. After two weeks, 1±0.1mm thick slice of coronal and apical radicular third of specimens was subjected to push-out testing using Universal testing machine. Subsequently the slices were observed under stereomicroscope for failure mode analysis.
Results: Data obtained was statistically analysed using independent t- test. Group UA demonstrated better bond strength than group NA both at coronal as well as apical levels. The mechanism of cavitation and acoustic streaming might be responsible for better adaptation to root dentin and subsequently better bond strength.
Conclusion: Ultrasonic activation of bioceramic sealer results in its increased adherence to root dentin.

Keywords: Bioceramic sealer, Ultrasonics, Push out Bond Strength,

INTRODUCTION

One of the important properties of root canal sealer is its firm adherence to root dentin. [1] Bonding of endodontic sealer to intraradicular dentin maintains the integrity of the sealer dentin interface during mechanical stresses caused by tooth flexure and also during preparation of postspace or operative procedures. [2] Also, a direct relationship between the endodontic sealer bond and leakage has been reported. [3] Endosequence BC sealer (Brasseler, Savannah, GA, USA) is a recently introduced bioceramic sealer based on calcium silicate composition. It is available as premixed, injectable paste containing water-free thickening vehicles and has excellent flow ability and dimensional stability. [2,4] It utilizes the moisture that remains within the dentinal tubules to initiate and complete its setting reaction. The major advantages associated with the use of bioceramic materials as root canal sealers are their excellent biocompatibility and formation of apatite like crystalline structure. [5] Ultrasonic activation of the endodontic sealers has been proposed to improve the quality of root filling. [6,7] The use of high frequency (25-30 KHz) ultrasonic devices promote acoustic transmission and cavitation, [8,9] which reduce the formation of voids in the filling material and also increase the interfacial adaptation between the sealer and canal walls. [6] This study evaluated the effect of ultrasonic activation of bioceramic sealer on its push-out bond strength. The null hypothesis was that ultrasonic activation do not influence bond strength.

MATERIALS & METHODS

Eighty adult human single rooted mandibular premolars with root curvature less than 20 degree were taken for the study. A standard root length of 13 mm was obtained after decoronation. The working length was established by subtracting 1mm from the total root length. A closed environment was created by placing the samples inside the polyvinyl siloxane material filled tubes for clinical simulation. Root canal shaping was done till

Protaper Universal F3 instrument (Dentsply Maillefer; Switzerland). 5 percent sodium hypochlorite (Septodont Healthcare India) and 17% EDTA (Prevest DenPro, India) solution was used for the irrigation of root canals. 3 ml of EDTA solution was used for 1 minute for effective management of smear layer and final rinse was done using distilled water. Canals were dried thoroughly with absorbent paper points and teeth were randomly divided into 2 groups each composed of 40 teeth depending upon the mode of sealer activation: Group UA, Ultrasonic activation and Group NA, No Activation (control). Bioceramic root canal sealer (Endosequence BC, Brassler, USA) was used as per manufacturer's instructions. The intracanal tip was placed in coronal two-third of canal and small amount of sealer dispensed (1 Calibration marking per canal) by compressing the plunger of the syringe. In group UA, size 15 ultrasonic K-file (SatelecActeon, USA) was attached to a piezoelectric ultrasonic handpiece (Satelec Acteon, USA) and used at medium power for the activation of the sealer. The file was activated for 30 seconds with 2-3 mm back and forth movements in the bucco-lingual direction and another 30 seconds in the mesio-distal direction of the root canal; 2 mm short of the working length as a standardization procedure. [6] All the samples in the group were then obturated with ProTaper F3 gutta-percha cones (DentsplyMaillefer; Switzerland). The access opening was sealed using temporary restorative material (Cavit G, 3M ESPE, Germany). In group NA, no activation was performed and canals were obturated using Protaper F3 gutta-percha followed by sealing of coronal orifices. The samples were incubated for 2 weeks at 37°C in 95% humidity for sealers to set.

Push Out Bond Strength Test

Each root was horizontally sectioned into 1.0 mm thick slices using a diamond disc under continuous water cooling. Slices with filling voids and non-circular shape were excluded. The diameter of the coronal and apical end of intracanal filling material was determined with a digital caliper. Apical and coronal end of each specimen was marked with indelible marker. The selected samples were placed on top of metallic jig with base orifice to allow the filling material to fall through after failure of the bond. Two slices from each root corresponding to coronal and apical third were selected. The push out test was performed using a universal testing machine (HEICO, New Delhi, India) at a crosshead speed of 1mm/min. Five plungers of different diameters (0.35mm, 0.5mm, 0.65mm, 0.8mm, 1.0mm) were used. Each sample was loaded in apical to coronal direction to avoid any interference from root canal taper during the test. Plunger size that provided 75 to 80% coverage of intracanal material without touching the circumferential dentin and base orifice diameter of jig close in size (0.7, 1.0, 1.3, 1.6 and 2mm), but slightly larger than diameter of intracanal material was selected for each specimen. The maximum load applied to the filling material before debonding occurred was recorded in Newton's (N).

Bond strength value (MPa) was calculated by using the following formula.[10]

Bond Strength= $\frac{F}{\pi(r+R)s}$

Where the slant height, s= $\sqrt{(R-r)2+h2}$

R and r being coronal and apical radius of filling material corresponding to bases of frustum and h is the slice thickness.

Mode of failure

Specimens were analyzed under stereomicroscope (Kyowa Getner, Japan) at 40× magnification to evaluate the failure modes as: Adhesive: no sealer present at the dentinal surface; Cohesive: dentinal surface completely covered by sealer; Mixed: sealer did not cover the entire dentinal surface.

Statistical Analysis

SPSS software 20.0 and Microsoft Excel were used for the analysis. Independent t-test was employed for intra-group analysis and inter-group analysis. A P-value of less than 0.05 was considered statistically significant.

RESULT

Mean (+/-S.D) of push out bond strength of the bioceramic sealer in coronal and apical regions of the root canal for both the groups is given in [Table 1]. In both groups, there was significantly greater bond strength in the coronal region of the canal than in the apical region. Intergroup comparison of bond strength has been depicted in [Table 2]. Ultrasonic activation (UA) resulted in significantly greater bond strength than the control group (NA) at coronal as well as apical levels. Failure mode analysis showed that cohesive failures mostly occurred in both groups followed by mixed failures and very low percentage of adhesive failures (Figure 1).

TABLE 1: Comparison between bond strengths obtained at coronal and apical levels.

Group	Mean push out bond strength (Mpa)
No Activation (NA)	
Coronal	6.36±2.3
Apical	4.10±0.7
P- Value	<0.001*
Ultrasonic Activation (UA)	
Coronal	7.52±3.04
Apical	5.09±2.4
P- Value	<0.001*

TABLE 2: Comparison of bond strengths between ultrasonic and no activation groups.

Group	Mean push out bond strength (Mpa)
Coronal	
No Activation (NA)	6.36±2.3
Ultrasonic Activation (UA)	7.52±3.04
P- Value	<0.001*
Apical	
No Activation (NA)	4.10±0.7
Ultrasonic Activation (UA)	5.09±2.4
P- Value	<0.001*

*Statistically Significant Difference (P-value <0.05)

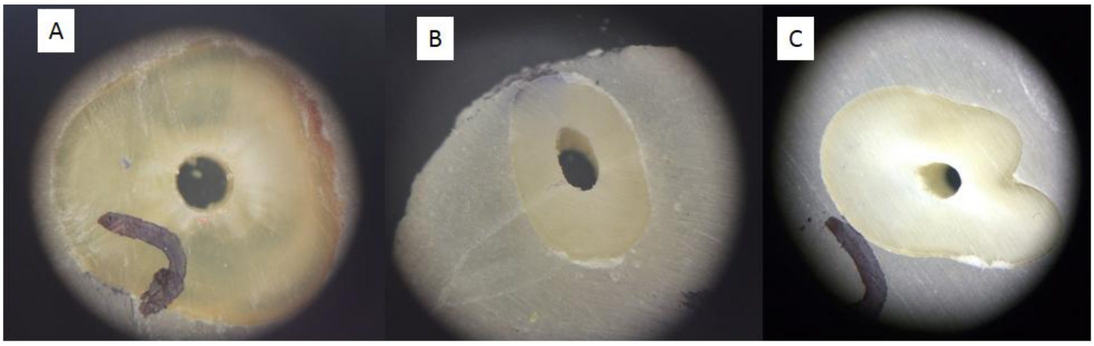

FIGURE 1: Cohesive failure (A), Mixed Failure (B), Adhesive Failure (C)

DISCUSSION

Bioceramic sealers have been recently introduced as root canal sealers to be used with conventional gutta-percha root filling. The manufacturers suggest that this sealer has features such as osteocon-ductivity, hydrophilicity, adhesiveness and chemical bonding to root canal dentinal walls. Zhang et al, [10] reported that bioceramic sealer does not shrink during setting and hardens in the presence of water. However every sealer should have sufficient bond strength to root dentin to prevent the microleakage in the root filling. Ultrasonics has been used in the past for the activation of root canal sealers for their better distribution throughout the root canal system. A recent study suggested that ultrasonic activation causes better adaptation and penetration of sealers into the dentinal tubules. [6] Push-out test has been widely used to evaluate the bond strength of root fillings. [11-13] Earlier studies on push-out bond strength used the same punch and base to test the bond strength on slices from different root thirds, despite the fact that the diameter of root canal decreases towards the apical direction. To overcome this, Stiegemeier et al, [14] utilized three different sized plungers to closely match the diameter of the root filling materials, obtained from different root levels. A study showed that orifice base diameter has a more significant effect on the stress distribution than did the punch diameter and recommended a base: punch ratio of around 1.7 for push-out test. [15] For this reason, both factors should be taken into account during push-out experimental tests. In this study five different plungers (0.35mm, 0.5mm, 0.65mm, 0.8mm and 1.0mm) and five different base orifice sizes (0.7mm, 1.0mm, 1.3mm, 1.6mm and 2mm) were used in order to determine the effect of base orifice size and plunger. In our study we found that ultrasonic activation yielded significantly better results than no activation in terms of bond strength. The results are in accordance with a previous study by Weiss et al. [16] Hence our null hypothesis was rejected. Ultrasonic activation has a direct action on the irrigation solution, displaces debris, and also induces turbulence of the solution. The frequent changes in hydrostatic pressure and the process of cavitation ultimately increase temperature and pressure. [17,18] High frequency ultrasonic energy with small oscillation amplitude provides sufficient energy for a more homogeneous setting of the sealer and a better packing of its filler particles. [19] Also, the heat generated during this process reduces sealer viscosity, better incorporation of filler particles into the organic matrix and thus improving the mechanical properties of the material. [20] This fact, combined with the increase of sealer pressure against the canal walls, allows a more effective filling of irregularities and of accessory canals. [7] Lower bond strength was observed in the apical region because the coronal root third has a greater number and diameter of dentinal tubules and also greater amount of intertubular dentine, favoring the adhesion of sealers to dentine walls. [21,22]

In the present study, the mode of bond failure was mainly cohesive followed by mixed and adhesive failures for both groups. This finding is in accordance with previous studies who showed that the failure mode for a calcium silicate-based sealer was mostly cohesive. [23,24]

CONCLUSION

Within the limitations of this study, we conclude that ultrasonic activation of bioceramic sealer causes a significant increase in sealer's bond strength to root dentin.

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