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Ultrasonic Activation of a Bioceramic Sealer and Its Dentinal Tubule Penetration: An In Vitro Study.

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ABSTRACT

Background: The root canal sealers form an important component of the three dimensional obturation of the root canals. Moreover, the penetration of the sealers into the dentinal tubules is a desirable phenomenon for their adequate sealing and antibacterial action. The aim of this study was to evaluate the effects of ultrasonic activation on the intratubular penetration of bioceramic root canal sealer. **Methods**: Eighty extracted human mandibular premolars were divided into 2 groups (n =40) according to the sealer activation method used to obturate the root canals instrumented with F3 Pro-Taper instruments .The canals were obturated using Protaper F3 guttapercha cones. Previously, the bio ceramic sealer was labeled with rhodamine B dye to allow analysis under a confocal microscope. The two groups were: UA (ultrasonically activated) and NA (no activation; control). All samples were sectioned at 3 and 8 mm from the apex. The percentages of dentinal sealer penetration segments of canal were analyzed. **Results**: Students T test was performed for the statistical analysis and we found that there was a significant increase in tubular penetration for the ultrasonic activation group.**Conclusion**: Use of ultrasonic activation of a bioceramic sealer promoted greater dentinal sealer penetration.

Keywords: Bioceramic sealer, Confocal microscopy, Ultrasonics

INTRODUCTION

Endodontic sealers are used in the obturation of root canal systems to achieve a fluid-tight seal throughout the canal and fill minor discrepancies between the dentinal wall of the root canal and the core filling material.[1] According to Sen et al, bacteria have been shown to penetrate 150 to 400 µm into dentinal tubules.[2] The ability of the sealers to penetrate into the dentinal tubules may be especially beneficial to control or kill bacteria that may be located there.[3] This tubular penetration has been suggested to enhance the sealing ability.[4] Bio-ceramic sealers have gained widespread popularity in recent times. Bioceramics are biocompatible, nontoxic, nonshrinking, and chemically stable within the biological environment. Another advantage of the material is its ability to form hydroxyapatite during setting process, thus forming a bond between dentin and filling material.[5,6] One of the popular bioceramic sealer is Endosequence Bioceramic sealer. Irrespective of sealer type,placement of a sealer into the root canal system should be done in a manner which is predictable, completely covers the dentin walls and at the same time favors its penetration into dentinal tubules. At the present time; no single technique has yet been proven to be completely satisfactory. Use of ultrasonic energy in endodontics was introduced by Richman in 1957. Properties of cavitation and acoustic streaming are apparently responsible for the enhanced canal system cleaning by ultrasonic devices. These same actions may result in a more thorough placement of a root canal sealer and can possibly favor its penetration inside the dentinal tubules. The effects of ultrasonic activation of the bio ceramic sealer into the root canal on its tubular penetration have not been explored sufficiently. In our research, we studied the effect of ultrasonic activation of a bioceramic sealer on its penetration into dentinal tubules.

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MATERIALS AND METHODS

A total of 80 adult human non carious single rooted mandibular premolars with root curvature less than 20 degree were taken for the study. Samples were decoronated to obtain a standardized root length of 13 mm. The working length was established by subtracting 1mm from the total root length. To simulate clinical condition, a closed environment was created by placing the samples inside the test tubes filled with polyvinyl siloxane material (Coltene; Switzerland). A custom made jig was used for instrumentation procedure. Root canal shaping was performed using ProTaper Universal rotary instruments (Dentsply Maillefer; Switzerland) at the working length until a F3 (30.05) instrument. 5 % sodium hypochlorite (Shivam, India) was used for the irrigation of root canals. 3 ml of 17% EDTA (PrevestDenPro,India) solution was used for 1 minute to remove the smear layer followed by a final rinse of 3 ml distilled water. Canals were dried thoroughly with absorbent paper points (DentsplyMaillefer; Switzerland). Samples were randomly divided into 2 groups each composed of 40 teeth depending upon the mode of sealer activation.

Group UA: Ultrasonic activation.

Group NA: No Activation (control)

Endosequencebioceramic sealer (Brasseler; USA) sealer is available in an automix tube form and thus requires no manipulation. After placing the extruded sealer on a mixing pad, it was labeled with trace amount of fluorescent Rhodamine B dye (HiMediaLaboratories;India).[7] The dye–sealer mixture was placed along the entire length of the root canal with size 25 lentulo spiral keeping the instrument 2 mm from the canal apices with the hand piece running at 300 rpm.[8] In group UA, size 15 ultrasonic K-file (SatelecActeon, USA) was attached to a piezoelectric ultrasonic handpiece (SatelecActeon, USA) and used at medium power for the activation of the sealer. Because the ultrasonic oscillates in a single plane, 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.[9] All the samples in the group were then obturated with ProTaper F3 gutta-percha cones (DentsplyMaillefer; Switzerland) and coronal orifices sealed with provisional restorative material. In group NA, no activation was performed after sealer placement and specimen were obturated. All the specimens were then stored in a humidifier with 100% humidity and temperature maintained at 37◦C for seven days. All the samples were sectioned horizontally with the help of diamond discs at the apical (3 mm from apex) and coronal (8mm from apex) levels of the root. The specimens were the discs uniformly 2 mm in thickness. Discs were cleared off the superficial debris by using fine sandpaper under running water. The segments of the root canal in which the sealer penetrated into the dentinal tubules were analyzed on an inverted Nikon A1+ confocal laser scanning microscope (Nikon Corporation Japan) by a method described by Guimarães et al.[9] The sections were analyzed 10 µm below the surface using the x10 lens. The respective absorption and emission wavelengths for the Rhodamine B were set to 540 and 590 nm, respectively. Then, the images were recorded using the fluorescent mode to a size of 512×512 pixels. Analysis of all images was performed with the Image J V1.46r software (National Institutes of Health, Bethesda, MD). The total circumference of the canal was obtained first. Then, segments of sealer penetration into the dentinal tubules were obtained and the values were converted into percentages.

Student's t-test was employed for intra-group analysis and inter-group analysis. A P-value of less than 0.05 was considered statistically significant.

RESULTS

Mean (+/-S.D) of dentinal tubule penetration of the 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 more sealer penetration in the coronal region of the canal than in the apical region [Figure 1]

Intergroup comparison of sealer penetration has been depicted in [Table 2]. Ultrasonic activation (UA) resulted in significantly better penetration into the dentinal tubules than the control group (NA) at coronal as well as apical levels [Figure 2]

Table 1: Comparison of results obtained at coronal and apical levels.

Group	Penetration (%)
NA	
Coronal Level	78.49±4.98
Apical Level	74.19±5.01
P Value	0.0002*
UA	
Coronal Level	82.97±5.21
Apical Level	78.39±5.48
P Value	0.0001*

*Statistically Significant Difference (P-value<0.05)

Table 2: Comparison of results obtained between control (NA) and ultrasonic activation (UA) group

Group	Level Penetration (%)
Coronal	
NA	78.49±4.98
UA	82.97±5.21
P value	0.0001*
Apical	
NA	74.19±5.01
UA	78.39±5.48
P value	0.0004*

*Statistically Significant Difference (P-value<0.05)

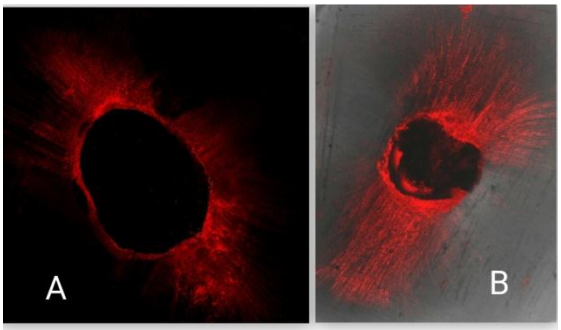

Figure 1: Sealer penetration in coronal (A) and apical (B) segments of ultrasonic (UA) group.

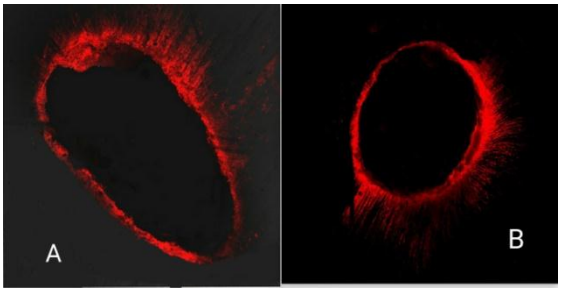

Figure 2: Sealer penetration in coronal (A) and apical (B) segments of control (NA) group

DISCUSSION

One of the recent advances in endodontic materials is Endosequence BC Sealer. It is a calcium silicate based BC sealer, described by its manufacturer as an insoluble, radiopaque, aluminum-free material that requires the presence of water to set and harden.[10] BC sealer is biocompatible, hydrophilic and expands on setting forming a 'self-seal'. This expansion can reach upto 0.2% on completion of setting reaction.[11] Expansion, chemical and micromechanical bonding all in total increase the bonding of the sealer to root canal walls. Also, high pH (12.8) during the initial 24 hours of the setting process makes this sealer strongly antibacterial. The present study was undertaken to study the effect of ultrasonic activation of bioceramic sealer on its tubular penetration. Sealer penetration into dentinal tubules could improve sealing of a root filling by increasing the surface contact area between the root filling materials.[12] It may also entomb any residual bacteria within the tubules and the chemical components of sealer cements may exert an antibacterial effect that will be enhanced by closer approximation to the bacteria.[13] Confocal laser scanning microscope was used in the study to measure percentage of sealer penetration into dentinal tubules. The use of the CLSM model allowed for a full cross-sectional observation, which clearly showed the amount of labeled sealer inside the dentin. CLSM does not require any special specimen processing, and observations can be made under environmental conditions. In our study we measured the segment of sealer penetration rather than the depth of penetration. The percentage of sealer penetration may be more meaningful and clinically relevant compared with the maximum depth of sealer penetration.[14] CLSM image analysis indicated that the methods of sealer placement used may not consistently and completely cover dentin walls after. Although sealer was present in the majority of the areas examined, the 3 mm level demonstrated significantly less ($P < 0.05$) sealer coverage than 8 mm level. In all three groups, the percentage of sealer penetration into dentinal tubules in the coronal was significantly greater in the coronal level than in the apical.

These findings are similar to other studies.[14-16] This could be because of the fact that a superior removal of the smear layer in the coronal and middle levels and the ineffective delivery of irrigant to the apical region of the canal occurs.[17] Another factor may be that the apical level contains less tubules, and when present, the diameter is smaller or they are more frequently closed.[18] Node production along activated file is an important part of acoustic streaming resulting in a strong current production along the activated instrument.[19] Ultrasonic energy has the ability to create several nodes along the length of file. This mechanism caused the increased tubular penetration of the sealer. Significantly better percentage of sealer penetration observed in ultrasonic group, substantiate the findings of previous studies.[20,21]

CONCLUSION

Ultrasonic activation of the sealer is an efficient method of sealer application and should be considered for contemporary endodontic therapy.

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