Original Article

Comparison of Three Different Sealer Placement Techniques: An *In vitro* Confocal Laser Microscopic Study

Abstract

Introduction: Three-dimensional obturation of the root canal system is the final objective of root canal therapy. Greater penetration of sealer in root dentine lesser will be the voids at the dentine–sealer interface. Hence, analysis of the dentin/sealer interface allows the determination of a filling technique which could obturate the root canals with least gaps and voids. Therefore, the aim of this study is to compare the depth and percentage of sealer penetration into root dentin using three different root canal sealer placement techniques under confocal laser scanning microscope. **Materials and Methods:** Thirty single-rooted teeth were selected and prepared. Adseal sealer (Meta Biomed, South Korea) was mixed with Rhodamine B dye and applied using lentulo spiral (Dentsply Maillefer, USA) as Group 1, bidirectional spiral (EZ-Fill– EDS, USA) as Group 2, and ultrasonic endodontic tip (Sonofile– Dentsply Tulsa, USA) as Group 3. Canals were then obturated with gutta-percha. The roots were sectioned at the 3 and 6-mm levels from the apical foramen and examined under confocal laser microscope. **Results:** Maximum mean depth and percentage of sealer penetration were observed for Group 1 and minimum for Group 3. Furthermore, statistical significant differences among Group 1 and Group 3 were found at 6-mm level and among Group 2 and Group 3 were found at 3-mm level ($P < 0.05$). **Conclusion:** The depth and percentage of sealer penetration of sealer are influenced by the type of placement technique and by the root canal level, with penetration decreasing apically. Lentulo spiral has shown better penetration of sealer than the bidirectional file and ultrasonics.

Keywords: *Adseal sealer, Bidirectional spiral, Confocal Laser Scanning Microscope, Lentulo spiral, Ultlrasonic Endodontic File*

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Introduction

Common failure of the root canal obturation is the presence of gaps and porosities at the sealer/dentin interface.[1] Obturated root canals can allow the re-colonization of microorganisms leading to failure of the root canal treatment and an urge for retreatment.[2] Therefore, for a good obturation, it is important to have sealer/dentin interface as great as possible.[3] There are various accepted means of sealer placement which includes the use of endodontic files or reamers, lentulo spirals, gutta-percha cones, paper points, and recently ultrasonic files.[4] The aim of this study was to compare the depth and percentage of sealer penetration into root dentin using three different root canal sealer placement techniques under confocal laser scanning microscope.

Materials and Methods

Specimen selection

Thirty single-rooted human maxillary teeth were selected. A dental operating microscope (Harisons Enterprises, New Delhi) was used to rule out cracks or apical resorption. Digital radiographs were taken in mesiodistal direction to ensure the presence of a single canal. Decoronation was done to standardize the root length to 10 mm using diamond disc under water.

Shaping and cleaning of root canal system

Working length was measured clinically by passing a size 10 K-file into each canal until it was seen through the apical foramen, and the length was measured. Working length was established by subtracting 0.5 mm from the measured length. Then, the root canals were instrumented using the Protaper Universal File System to a size of F3 using

How to cite this article: Dash AK, Farista S, Dash A, Bendre A, Farista S. Comparison of three different sealer placement techniques: An *In vitro* confocal laser microscopic study. Contemp Clin Dent 2017;8:310-4.

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Website: www.contempclindent.org
DOI: 10.4103/ccd.ccd_1109_16
Quick Response Code:

2 ml solution of 3% sodium hypochlorite for each file used during the root canal shaping. To eliminate the smear layer, 2-ml 17% EDTA for 3 min was used followed by a final rinse of 2 ml distilled water. Each root canal was dried with paper points and was randomly divided into three groups according to the sealer placement technique used: ultlrasonic endodontic tips (Sonofile– Dentsply Tulsa, USA), bidirectional spiral (EZ-Fill– EDS, USA), and lentulo spiral (Dentsply Maillefer, USA).

Sealer preparation

Adseal (Meta Biomed, South Korea) was mixed according to manufacturer's instructions. To allow analysis under the confocal laser scanning microscope (LSM 800, Carl Zeiss Microscopy, US), each sealer was labeled with Rhodamine B (Sigma-Aldrich, St. Louis, MO, USA) to an approximate concentration of 0.1%.

Sealer placement

A 1-mL tuberculin syringe was used to dispense 0.05 mL inside each canal. No additional sealer was used.

Group 1 (Gr-1): A size 25 lentulo spiral was used according to manufacturer's instructions, keeping the instrument up to working length for 5 seconds. Canal was obturated with ProTaper F3 gutta-percha cone. Gutta-percha was compacted 1 mm below the canal orifice and the teeth were sealed with Cavit.

Group 2 (Gr-2): A size 25 bidirectional spiral was used according to manufacturer's instructions, keeping the instrument up to working length for 5 seconds. Thereafter, the obturation of canal was conducted as described for Group 1.

Group 3 (Gr-2): The ultrasonic endodontic tip K-25 Sonofile was used in endo mode with an Ultrasonic unit for activation of sealer. The file was inserted up to working length inside the canal and was ultrasonically activated for 5 seconds at a setting of 3. Thereafter, the obturation of canal was conducted as described for Group 1.

Sectioning and image analysis

All the roots were stored in container at 100% humidity and 37°C for 7 days to allow the sealer to set. The roots were sectioned using a diamond disc under continuous water cooling to prevent frictional heat. Horizontal sections were done at the 3 and 6 mm levels from the apical foramen. Then, the surface was polished using sandpaper number 600 under running water to eliminate debris product of the cutting procedure. Two millimeter thick samples were submitted to confocal laser microscopy under ×10 magnification. The respective absorption and emission wavelengths for the Rhodomine B were 540 nm and 590 nm.

To calculate the percentage of sealer penetration around the root canal, first each image was imported into the LSM image browser and the circumference of root canal measured. Next, areas along the canal walls in which the sealer penetrated into dentinal tubules were outlined and measured using the same method. Subsequently, the percentage of root canal sealer penetration in that section was established [Figure 1]. Statistical significance for the percentage of root canal was determined for each level of the root canal using analysis of variance (ANOVA) followed by Tukey's test; the level of significance was set at $P < 0.05$.

Using the ruler tool of the LSM image browser software, depth of sealer penetration was measured and recorded at four standardized points of each ×10 picture as described by Gharib *et al*.[5] The canal wall served as the starting point and sealer penetration into dentinal tubules was measured to a maximum depth of 1000 μm [Figure 2]. These data points were averaged to obtain a single measure for each section. Statistical significance for the mean of depth penetration of root canal sealers was determined for each level of the root canal using ANOVA followed by Tukey's test; the level of significance was set at $P < 0.05$.

Results

From the three placement techniques, 60 sections were evaluated at the 3 and 6-mm levels. All the analyzed activation techniques failed to show a consistent adaptation of sealers to the total circumference of the root canal walls. The mean and standard deviation of sealer penetration depth and percentage of sealer penetration are presented in [Table 1]. Group 1 showed maximum mean depth of penetration and maximum mean percentage of sealer penetration, whereas Group 3 showed minimum mean depth of penetration and minimum mean percentage of sealer penetration. Results also demonstrated that the mean depth of penetration and percentage of penetration was less at 3 mm level than at 6-mm level. A statistical significant difference was seen among Group 1 and Group 3 at level 6 and Group 2 and Group 3 at level 3 [Table 2].

Discussion

Major goal of root canal filling is to prevent any interchange between the oral cavity, the root canal system, and the periradicular tissues, providing a barrier to canal infection and reinfection. Removal of smear layer and use of sealer is considered an essential as sealers are used to attain an impervious seal between the core material and root canal walls.[6,7] Most of the studies have shown that use of sealer along with core material results in significantly less leakage than when it is not use.[7]

The penetration of sealer into dentinal tubules is considered to be a desirable outcome for a number of reasons: it will increase the interface between material and dentin thus improving the sealing ability, and retention of the material may be improved by mechanical locking, entomb any residual bacteria within the tubules and the chemical components of sealer cements may exert an antibacterial effect. Therefore, for a good obturation, it is important to have sealer/dentin interface as great as possible.[3]

The depth of sealer penetration in the dentinal tubules depends on many factors such as smear layer removal, dentinal permeability (the number and the diameter of tubules), root canal dimension, presence of water and the physical, and chemical properties of the sealer.[8] The flow is one of the main physical factors to influence the tubular penetration. The flow is determined by the consistency, particle size, shear rate, temperature, time, internal diameter of the root canal, and the rate of insertion.[9] As most endodontic sealers are pseudoplastic, their flow increases with increase of shear rate. In the present study temperature, amount and time for placement are kept constant to minimize the errors.

Table 1: Comparison of percentage of area of penetration

	Group 1	Group 2	Group 3
Depth of penetration			
Level 3			
Mean	90.2	49.2	49.7
SD	56.4	29.7	68.7
Level 6			
Mean	107.6	82.4	66.1
SD	52.9	45	62.9
Percentage of area of penetration			
Level 3			
Mean	46	34.2	22.2
SD	22.9	14.5	10.8
Level 6			
Mean	90.2	49.2	49.7
SD	56.4	29.7	68.7

SD: Standard deviation

As very few studies have been conducted on the effect of sealer activation/placement and activation on sealing ability of root canal sealers.[9] Therefore, in the present study, three activation techniques (lentulo spiral, bidirectional spiral, and ultrasonics) were chosen and the sealer distribution was analyzed.

The apical 5 or 6 mm of a root canal is a critical area for placement of sealer as accessory canals are most often found in this area. Since accessory canals communicate with the periodontal membrane, they can create a periodontic-endodontic pathway for potential bacterial penetration to and from the periodontium.[10] Thus, the apical third of root canal was chosen for the evaluation of sealer.

In the present study, a new sealer Adseal was used. To the best of our knowledge, few studies are done using this sealer. These sealers have root canal adaptation, solubility,

Table 2: Intergroup comparison and level of significance

Group	Depth of penetration				Percentage of area of penetration			
	Level 3		Level 6		Level 3		Level 6	
	P	Significance	*P*	Significance	*P*	Significance	*P*	Significance
Group 1 and 2	0.057	NS	0.26	NS	0.99	NS	0.19	NS
Group 2 and 3	0.98	NS	0.51	NS	0.02	Significance	0.05	NS
Group 1 and 3	0.16	NS	0.12	NS	0.06	NS	0.008	Significance

NS: Not significant

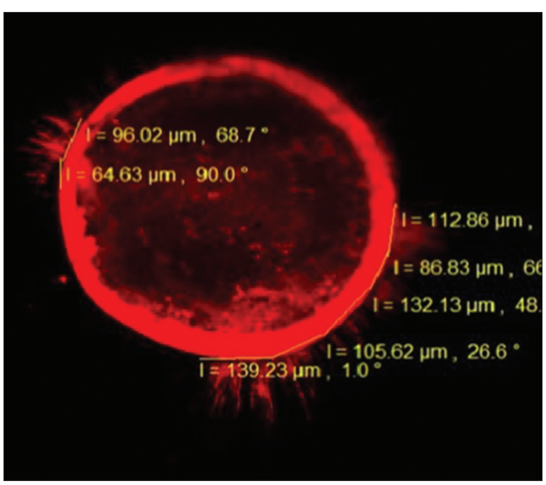

Figure 1: Confocal laser scanning microscopic image for measuring percentage of sealer penetration using laser scanning microscope image browser

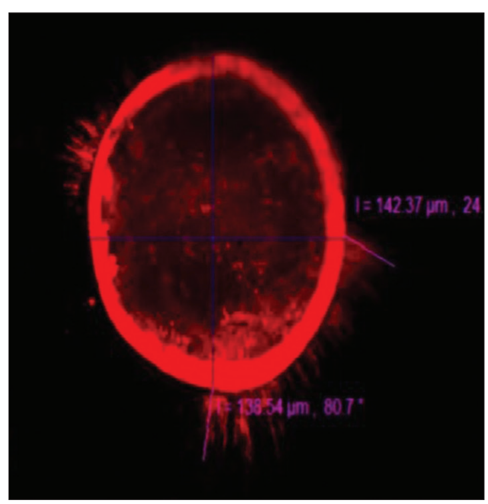

Figure 2: Confocal laser scanning microscopic image for measuring depth of sealer penetration using laser scanning microscope image browser

flow, and film thickness similar to AH plus which considered as Standard and is most commonly used.[11]

Several microscopy techniques are available to evaluate the sealer/dentin interface, including stereomicroscopy, scanning electron microscopy, transmission electron microscopy, and confocal laser scanning microscopy (CLSM). CLSM offers several advantages like the use of nondecalcified or hard tissue samples that do not require a specific section technique (sputter coating). It also provides detailed information about the presence and distribution of sealers at relative low magnification through the use of fluorescent Rhodamine-marked sealers and allows the exclusion of artifacts from the sample.[12]

The results of this study indicate that all three methods of sealer placement may not consistently and completely cover dentin walls after obturation. Although sealer was present in the majority of the areas examined, the 3-mm level demonstrated less sealer coverage than 6-mm level. Not only the coverage but also the penetration of the sealer into the dentinal tubules was more at the 6-mm level than 3-mm level of the root canal irrespective of method of sealer placement which corroborates the findings of Nikhil *et al*. 2013.[9]

Reason for this can be number and diameter of dentinal tubules which decreases on descending apically in the root canal; removal of smear layer is less at the apical third, apical dentin is irregular in direction and density. Furthermore, some areas are devoid of dentinal tubules, cementum-like tissue can line the apical root canal wall occluding tubules. Some amount of moisture is left in root canal even after drying due to capillary action in narrow apical third of canal thus, limiting the flow of sealer in the apical third.[13]

Overall lentulo spiral group (Gr-1) showed better depth and percentage of sealer penetration than ultrasonic (Gr-3) which is in corroboration with Kahn *et al*.[14] and Agrawal *et al*.[15] This can be because lentulo spiral has an action such that it pushes the sealer centrifugally whereas ultrasonic files propels the sealer along the length of file. Ultrasonic energy has the ability to create several nodes along the length of file. Poor percentage of sealer penetration and depth of sealer penetration in the apical area might be due to the activated ultrasonic file touching the canal wall in the more constricted area and not being able to produce the necessary nodes for acoustic streaming and cavitation.[9]

Bidirectional file group (Gr-2) shows similar results as lentulo spiral group (Gr-1) which are similar to findings of Wiemann and Wilcox,[16] Parikh *et al*.,[17] and Kim *et al*.[18] Bidirectional spiral coats the canal walls and prevents the excess cement from exiting apically. Coronal grooved spirals travelling on the apical direction carry the cement apically while the apical reverse spirals flow the cement in coronal direction simultaneously. The two independent flows of cement collide where the grooved spirals change direction. At the point of Collison, cement flow is forced to travel laterally filling the lateral canals.[17]

Conclusion

Within limitations of this study, it can be concluded that depth and percentage of sealer penetration of sealer are influenced by the type of placement technique and by the root canal level, with penetration decreasing apically. All the analyzed placement techniques failed to show a consistent adaptation of sealer to the total circumference of the root canal wall. Lentulo spiral has shown better penetration of sealer than the bidirectional file and ultrasonics.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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