Abstract

Background: Complete seal at dentin-sealer-core interface of the root canal is required to maintain long-term periapical health.

Aim: The aim of this in vitro scanning electron microscopic (SEM) study was to determine which of the commonly used root canal sealer among AH-Plus, GuttaFlow, and RealSeal provides a superior marginal adaptation with the dentin in the apical third region of root canals.

Materials and Methods: Selected 30 human freshly extracted maxillary central incisors were biomechanically prepared, then divided equally into three groups and obturated with AH-Plus, GuttaFlow, and RealSeal using single-cone obturation technique. After sectioning longitudinally, apical third of the roots was observed under SEM; dentin-sealer-core interface was focused. Marginal adaptation and interfacial gaps at dentin-sealer interface of all the samples were evaluated and analyzed statistically in this part of the article.

Statistical Analysis Used: Analysis of variance and post hoc Tukey’s test.

Results: GuttaFlow exhibited least average marginal gap of 2.38 ± 1.43 µm, followed by AH-Plus (4.11 ± 2.85 µm) and RealSeal (4.65 ± 3.91 µm) with no significant difference (P > 0.05) among the groups.

Conclusions: As the dentin-sealer interfacial gap is seen to be minimum in GuttaFlow, it is better adapted to dentin in the apical third of root canals compared to AH-Plus and RealSeal.

Keywords: AH-Plus; dentin-sealer interface; GuttaFlow; marginal adaptation; RealSeal; scanning electron microscope

INTRODUCTION

Root canal sealers play a critical role in the success of endodontic therapy by eliminating the space between the root canal wall and core filling material.[1] However, microscopic gaps between the sealer and dentin and sealer and core obturating material jeopardize the outcome of root canal treatment, and marginal leakage through these gaps continues to be a major reason for the failure of root canal therapy.[2] To minimize marginal gaps between sealer and dentin, there has been continuous search for alternative endodontic sealers which could adhere to dentin. Among them, commonly used are AH-Plus, GuttaFlow, and RealSeal. Along with the first two sealers, gutta-percha is used as a core obturating material whereas a polymer: polycaprolactone-dimethacrylate core (Resilon) is used when RealSeal is used as a sealer.
AH-Plus, an epoxy resin-based sealer, has shown to produce high bond strength to the canal wall and an adequate long-term dimensional stability. However, inferior sealing ability of AH-Plus has been reported in some studies.

RealSeal sealer, a dual cure methacrylate resin which bonds to the etched root surface and to the Resilon core, has been claimed to form monoblock by the manufacturers. Many in vitro leakage studies have shown superior seal of this sealer over other conventional root canal sealers; however, results in other studies appear to be contrasting, and also whether a monoblock is achievable remains controversial.

GuttaFlow, a cold flowable obturation system, was introduced with the intention of reducing the disadvantage of warm gutta-percha technique and providing better seal as compared to other sealers. However, some studies have shown equal/inferior sealing ability of GuttaFlow as compared to other sealers.

Conflicting results of sealing ability of these commonly used sealers demand further studies for comparative evaluation of marginal adaptation of these commonly used sealers.

Therefore, the purpose of this scanning electron microscopic (SEM) study was to determine which root canal sealer among AH-Plus, GuttaFlow, and RealSeal provides a superior marginal adaptation with the dentin (subject matter of this part of the article) and with the core obturating material (discussed in Part II of this article) at apical portal of entry, i.e., in the apical third region of root canals.

MATERIALS AND METHODS

Thirty human maxillary central incisors, freshly extracted for periodontal cause, free from any open apices, cracks, calcified canals, canal curvature, and resorptive defects were selected for this study. Informed consent was obtained from the patients, and the Institutional Ethics Committee and Review Board gave ethical clearance for this study. Instrumentation was completed using crown-down technique with Profile ISO series rotary files until a size 40; 0.06 reached working length. Ethylenediaminetetraacetic acid was used as the final rinse before root canal obturation.

Then, teeth were randomly divided into three experimental groups (Group I, II, III) of ten sample each.

For the teeth in Group I, AH-Plus (Dentsply MAILLEFER, Ballaigues, Switzerland) was used as a sealer after mixing its two components and introduced in the canal with size 40; 0.06 master cone gutta-percha.

In Group II, GuttaFlow (Coltene WHALEDENT, DPI, Mumbai, Maharashtra, India) was used as sealer along with size 40; 0.06 gutta-percha mastercone. GuttaFlow provided in single-use capsules was used in the study as per manufacturer’s instructions.

The prepared canals of teeth in Group III were conditioned with two to three drops of self-etch primer of RealSeal (SybronEndo, Orange, CA, USA) dispensed with a syringe on orifice and applied evenly on the canal wall with the brush provided by the manufacturer. Any excess primer was removed with paper points. Resilon core master cone of size 40; 0.06 coated with the RealSeal sealer was placed in the root canal.

All the sample teeth were obturated using single-cone obturation technique. The RealSeal sealer used in Group III was polymerized for 40 s in the coronal portion. The root canal opening of all three groups was then sealed with glass ionomer cement.

Obturated teeth were stored at 37°C and 100% humidity for 7 days. Each root was then longitudinally sectioned using a diamond disk on a slow-speed handpiece to obtain the dentin-root canal filling interface at apical 3 mm of root. During sectioning, the specimens were subjected to continuous water cooling to prevent frictional heat, which minimizes smearing of core obturating materials that tend to hide areas of sealer as pointed by Vikram et al. Apical third sections thus obtained were labeled accordingly.

All specimens were dehydrated in an ascending series of aqueous ethanol (70%, 80%, 90%, 95%, 100%); then, gold sputtered and observed under SEM using high accelerating voltage of 15.0 kV at different magnifications ranging from ×25 to ×2000 to achieve a representative area containing both gap-containing and gap-free region and visualize a broader aspect of sample.

Under SEM, two-three representative areas from middle third of each sample were focused, and dentin-sealer interfacial gaps were measured using ImageJ software (Wayne Rasband; National Institute of Health, Bethesda, MA, USA). Overall average gaps at this interface were calculated for each sample and were tabulated [Table 1].

Statistical analysis was performed with the help of Epi Info (TM) 3.5.3 (Centers for Disease Control and Prevention(CDC), Atlanta; Georgia[US]). One-way analysis of variance (ANOVA) followed by post hoc Tukey’s test was performed with the help of critical difference (CD) or least significant difference at 5% and 1% level of significance to compare the mean values. \( P < 0.05 \) was taken to be statistically significant.
RESULTS

1. None of the groups showed complete marginal adaptation at dentin-sealer interface [Table 1 and Figure 1]

2. There were both gap-free and gap-containing regions at different levels in all groups. However, GuttaFlow exhibited better apical marginal adaptation to dentin [Figure 1a and b] than RealSeal [Figure 1c and d] and AH-Plus [Figure 1e and f]

3. At dentin-sealer interface, maximum mean average gap was seen for RealSeal samples: 4.65 ± 3.91 µm, followed by AH-Plus samples: 4.11 ± 2.85 µm, and it was minimum for GuttaFlow samples which was 2.38 ± 1.43 µm [Table 1].

Statistical analysis ANOVA followed by post hoc Tukey’s test with the help of CD showed no significant difference in mean average gap at dentin-sealer interface among the three groups (P > 0.05) [Table 1].

DISCUSSION

Most critical area of prepared root canal is the apical 2–3 mm, hence, sealing ability of the commonly used three sealers was evaluated in the apical third region in the present study.

Seal along the dentin-sealer and also at core-sealer interface prevents percolation and leakage of fluids thereby preventing reinfection. This part of the present study will focus on comparative evaluation of marginal gap of AH-Plus, GuttaFlow, and RealSeal at dentin-sealer interface using SEM.

Leakage studies have been widely used in the past for assessment of sealing ability of root canal sealers. However, leakage evaluations show great variations in studies, and the results are often contrasting. In the present study, the quality of the root canal seal was assessed through a histological method by SEM evaluation. SEM has larger depth of field, higher resolution, and better magnification at the interface which has been also pointed by Punithia and Shashikala.

Single-cone obturation was done in the present study to simulate most common method employed in clinical practice.

Table 1: Analysis of dentin-sealer interfacial gap (µm)

| Sample number | Group I: AH-Plus | Group II: GuttaFlow | Group III: RealSeal |
|---------------|------------------|---------------------|---------------------|
| 1             | 1.879            | 2.516               | 5.954               |
| 2             | 1.829            | 2.125               | 2.436               |
| 3             | 3.963            | 0.634               | 0.493               |
| 4             | 1.443            | 2.242               | 2.703               |
| 5             | 6.213            | 3.30                | 1.364               |
| 6             | 10.109           | 0.896               | 9.358               |
| 7             | 3.109            | 4.112               | 0.77                |
| 8             | 1.107            | 2.595               | 6.491               |
| 9             | 5.517            | 1.304               | 4.677               |
| 10            | 5.989            | 5.007               | 12.319              |

Mean±SD 4.11±2.85 2.38±1.43 4.65±3.91 Median 3.536 2.379 4.690 Range 1.107-10.109 0.634-5.007 0.493-12.319

ANOVA F 1.65 P 0.21 (i.e., P>0.05)

Post hoc Tukey’s test

| CD<sub>5</sub> | Group I versus Group I versus Group II Group II Group III versus Group III (P>0.05) (P>0.05) |
|---------------|---------------------------------------------------|
| C1<sub>1</sub> | Group I versus Group I versus Group II Group II Group III versus Group III (P>0.01) (P>0.01) |

*At 5% level of significance, †At 1% level of significance. ANOVA: Analysis of variance, SD: Standard deviation.
scenario and to maintain homogeneity among groups. The use of a single-cone filling technique is often considered inferior to more sophisticated three-dimensional compaction techniques. However, it must be noted that the concept of the single-cone technique has been recently revisited by Wu et al. and the volume of the sealer used in the present study was minimized because calibrated gutta-percha and Resilon cones were used in the prepared canal.

In the present study, GuttaFlow exhibited better adaptation [Figure 1a and b] with least mean marginal gap at dentin-sealer interface compared to RealSeal and AH-Plus [Table 1]. Better adaptation of GuttaFlow to root canal dentin is also found in studies of Nawal et al., Bouillaguet et al., Vujasković and Teodorović, and Teodorović and Matović. Better sealing ability of GuttaFlow is also found in other leakage studies.

This better sealing ability exhibited by the GuttaFlow could be attributed to its ability to flow into the main root canal, into lateral canals, recesses, or any grooves, and also it has shown good penetration into the dentinal tubules. Apart from this, GuttaFlow obturation system exhibits a linear setting expansion of 0.16%, following obturation in the canal. In addition, placement of gutta-percha cone pushes the material into the lateral and accessory canal which may be responsible for its better seal as pointed by Ozok et al. possibly because of its thixotropic nature as claimed by manufacturer.

However, inferior sealing ability of GuttaFlow has also been found in the dye leakage and glucose penetration model studies. Such differences in performance may be attributed to the method used for evaluation and/or lateral compaction obturation technique employed in these studies.

RealSeal sealer, a methacrylate resin, claimed to form monoblock by the manufacturers, showed greater mean marginal gap compared to GuttaFlow and AH-Plus [Table 1]. Micromechanical bond between RealSeal and root canal dentin depends on many factors which are as follows:

a. Polymerization interfacial stresses generated due to intrinsic volumetric shrinkage can be high enough to debond adhesive interface.
b. Extremely high C-factor (ranged from 46 to 23,461) in root canals has been cited as a possibility for not achieving perfect seals in Resilon-filled root canals.
c. Uniform application of a primer or adhesive in the apical one-third is difficult. Once the primer is applied, the volatile carrier must be evaporated. This can also be problematic in the apical one-third. Incomplete evaporation of the primer solvent promotes formation of a hydrogel which is inherently leaky and severely affects bonding.
d. Furthermore, manipulation of partially polymerized sealer during condensation may disrupt developing bonds between self-etch primer and root dentin.

All these above factors make bonding of methacrylate resin-based sealers to root canal dentin unpredictable, thus, formation of monoblock is questionable. This is possibly reflected in SEM image where sealer in some places is well adapted to dentin whereas in some places, there is wide gap. This heterogeneous distribution of the methacrylate resin-based sealers is also reported by Bouillaguet et al.

AH-Plus exhibited slightly less mean marginal gap than that of RealSeal, with no statistically significant difference between the two [Table 1]. This finding is in agreement with the study of Tay et al. Adaptation of AH-Plus to dentin [Figure 1e and f] is due to its flow and long setting time. AH-Plus sealer penetrates deeper into the surface microirregularities as well as inside the lateral root canals. However, this group exhibited greater mean marginal gap when compared to GuttaFlow Group [Table 1], which could be due to the linear setting shrinkage of 0.034% ± 0.01% in AH-Plus.

CONCLUSION

Under the parameters and limitations of the present study, it may be concluded that GuttaFlow exhibited better adaptation at dentin-sealer interface at apical third of root canal when compared with RealSeal and AH-Plus sealers.

Nevertheless, results of this in vitro study need to be confirmed through further in vivo, in vivo, and ex vivo studies with large numbers of samples for longer period of time to arrive at a conclusion.

Limitation of the present study

- There is a great risk that sectioning of the filled canal may result in tearing of the material or smearing of the gutta-percha and Resilon that tend to hide areas of sealer
- Examination of fully hydrated specimens by environmental scanning electron microscopy is essential for differentiating genuine gaps between root filling and dentin, from potential artifactual gaps created after vacuum desiccation in conventional SEM followed in this study.

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Conflicts of interest
There are no conflicts of interest.

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