Scanning electron microscopic evaluation of marginal adaptation of AH-Plus, GuttaFlow, and RealSeal at apical one-third of root canals – Part II: Core-sealer interface

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Abstract
Background: Not only the gaps at dentin-sealer interface but also at core-sealer interface may jeopardize the outcome of root canal treatment.

Aim: The aim of this in vitro 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 core obturating material 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 were observed under SEM dentin-sealer-core interface was focused. Marginal adaptation and interfacial gaps at core-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: Mean average gap was significantly higher ($P < 0.05$) for AH-Plus ($15.65 \pm 10.48 \mu m$), when compared to GuttaFlow ($3.51 \pm 1.81 \mu m$) and RealSeal ($6.01 \pm 2.51 \mu m$). Between RealSeal and GuttaFlow, the latter showed least marginal gap; however, this difference was not statistically significant ($P > 0.05$).

Conclusions: GuttaFlow is better adapted in the apical third of root canals among 3 sealers.

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

INTRODUCTION

Complete sealing of the root canal system after cleaning and shaping procedure is critical to prevent oral pathogens from colonizing and reinfecting the root and periapical tissues.\(^\text{[1]}\) Marginal leakage could occur at the interface between the sealer-dentin as well as sealer-core obturating material.\(^\text{[2]}\) In recent years, there has been continuous quest for such type of sealers that adhere simultaneously to canal wall dentin as well as core obturating materials, in an attempt to seal the root canal system more effectively. With this goal in mind, the purpose of present in vitro scanning electron microscopic (SEM) study is to determine which one of the commonly used root canal sealers among AH-Plus, GuttaFlow, and RealSeal provides a superior marginal adaptation both at dentin-sealer and core-sealer interface in the apical third region of root canals. Quality

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of seal along dentin-sealer interface has been evaluated quantitatively in Part I of this article whereas core-sealer interface has been focused here in this part.

**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 through 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.

All three endodontic sealers were mixed and used according to manufacturer’s instructions and introduced into the canal space with master cone size 40:0.06. The teeth of Group I, Group II, and Group III were obturated with AH-Plus (Dentsply Maillefer, Ballaigues, Switzerland), GuttaFlow (Coltene Whaledent, DPI, Mumbai, Maharashtra, India), and RealSeal (SybronEndo, Orange, CA, USA) sealers, respectively, using mastercone gutta-percha in Group I and II and Resilon master cone in Group III. Single-cone obturation technique was employed.

The root canal opening of all three groups was then sealed with glass ionomer cement, and 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.[3] 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 core-sealer interfacial gaps were measured using ImageJ software[3] (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]). EPI INFO is a trademark of the Centers for Disease Control and Prevention. 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. To compare the means of 2 populations, t-test was used. P ≤ 0.05 was considered statistically significant.

**RESULTS**

1. None of the groups showed complete marginal adaptation at core-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 with core obturating material [Figure 1a and b] than RealSeal [Figure 1c and d] and AH-Plus [Figure 1e and f] at core-sealer interface, mean average gap was maximum for AH-Plus: 15.65 ± 10.48 µm, followed by RealSeal: 6.01 ± 2.51 µm and it was minimum for GuttaFlow which was 3.51 ± 1.81 µm [Table 1]. Statistical analysis ANOVA showed statistically significant difference among the three groups (P < 0.05) [Table 1]. Post hoc Tukey’s test with the help of CD showed mean average gap of AH-Plus was significantly higher than that of GuttaFlow and RealSeal at 5% level of significance (P < 0.05); however, there was no significant difference between GuttaFlow and RealSeal (P > 0.05) [Table 1]
3. When compared to dentin-sealer interface (as discussed in Part I), gap at core-sealer interface in AH-Plus group was significantly high (P < 0.05) [Figure 1e and f], whereas that in GuttaFlow and RealSeal group, no significant difference (P > 0.05) was seen [Table 2].

**DISCUSSION**

Peripheral gaps along the dentin-sealer and core material-sealer interfaces may jeopardize the outcome of root canal treatment. This part of the present study focused on comparative evaluation of marginal gap of AH-Plus, RealSeal, and GuttaFlow sealers at core-sealer interface using SEM. Marginal adaptation at the apical third region was assessed, as most critical area of prepared root canal is the apical 2–3 mm.
Leakage studies using different methods to assess apical seal have shown conflicting results. Hence, the present study aimed to look at the core-sealer interface using 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 technique was employed as it is the most common method employed in clinical scenario and volume of the sealer was minimized because size and taper of gutta-percha and Resilon master cones were calibrated to the preparation size and taper.

In the present study, GuttaFlow (Group II) exhibited better adaptation [Figure 1a and b] and least mean marginal gap at core-sealer interface compared to RealSeal and AH-Plus [Table 1]. The result of the present study (both Part I and Part II) that GuttaFlow shows better adaptation with both dentin and gutta-percha is also supported by the studies Vujasković and Teodorović, Teodorović and Matović, and Bouillaguet et al.

Better sealing ability of GuttaFlow is also found in other leakage studies. This better adaptation of GuttaFlow to gutta-percha is mainly attributed to linear setting expansion of 0.16%, following obturation in the canal and ability to flow into the canal. 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.

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

| Groups       | Core-sealer interface | Dentin-sealer interface | t<sub>18</sub> | P         |
|--------------|-----------------------|-------------------------|----------------|-----------|
| Group I:     | 15.65±10.48           | 4.11±2.85               | 3.36           | 0.0035    |
| AH-Plus      | Mean±SD               |                         |                |           |
| Median       | 12.114                |                         |                |           |
| Range        | 3.124-34.704          | 0.580-6.960             | 1.872-11.250   |           |
| Group II:    | 3.51±1.81             | 2.38±1.43               | 1.54           | 0.14      |
| GuttaFlow    | Mean±SD               |                         |                |           |
| Median       | 3.223                 |                         |                |           |
| Range        | 0.580-6.960           | 0.634-5.007             | P>0.05         |           |
| Group III:   | 6.01±2.51             | 4.65±3.91               | 0.92           | 0.35      |
| RealSeal     | Mean±SD               |                         |                |           |
| Median       | 5.998                 |                         |                |           |
| Range        | 1.872-11.250          | 0.493-12.319            | P>0.05         |           |

*Refer to of Part 1 of the article. SD: Standard deviation

### Table 2: Comparison of dentin-sealer and core-sealer interfacial gaps (µm)

| Groups       | Parameters | Core-sealer interface | Dentin-sealer interface | t<sub>18</sub> | P         |
|--------------|------------|-----------------------|-------------------------|----------------|-----------|
| Group I:     | Mean±SD    | 15.65±10.48           | 4.11±2.85               | 3.36           | 0.0035    |
| AH-Plus      | Median     | 12.114                |                         |                |           |
|              | Range      | 3.124-34.704          | 0.580-6.960             | 1.872-11.250   |           |
| Group II:    | Mean±SD    | 3.51±1.81             | 2.38±1.43               | 1.54           | 0.14      |
| GuttaFlow    | Median     | 3.223                 |                         |                |           |
|              | Range      | 0.580-6.960           | 0.634-5.007             | P>0.05         |           |
| Group III:   | Mean±SD    | 6.01±2.51             | 4.65±3.91               | 0.92           | 0.35      |
| RealSeal     | Median     | 5.998                 |                         |                |           |
|              | Range      | 1.872-11.250          | 0.493-12.319            | P>0.05         |           |

*At 5% level of significance, †At 1% level of significance. ANOVA: Analysis of variance, SD: Standard deviation

Figure 1: Scanning electron microscopic images: Core-Sealer interface – (a and b) GuttaFlow, good adaptation with minimal gap. (c and d) RealSeal, heterogeneous distribution with gaps at some places. (e and f) AH-Plus, wide gaps seen. D: Dentin, S: Sealer, C: Core
In RealSeal (Group III), despite chemical bond between Resilon cone and RealSeal sealer, surprisingly mean average gap of 6.01 ± 2.51 µm occurred at core-sealer interface [Table 1], which could be possible due to the following reasons:

a. The concentration of the polymeric components, polycaprolactone and urethane dimethacrylates is probably in the ratio of 10:1 in Resilon core, which may not be optimized for optimal adhesion of the root filling material to the methacrylate resin-based sealers.[17,18]

b. Morphologic studies further revealed that the dimethacrylate in Resilon is not homogeneously dispersed within the polymer blend and appeared as phase separation components within the polycaprolactone.[17,19]

c. As Resilon is used commercially as a fully polymerized material that lacks a free radical-containing oxygen inhibition layer, its bondability to resin-based sealers has further been questioned.[17]

All these above factors make bonding unpredictable at core-sealer interface.[20,21] This is possibly reflected in SEM image [Figure 1c and d] where sealer in some places is well adapted to Resilon whereas in some places, there is a gap. This heterogeneous distribution of the methacrylate resin-based sealer is also reported by Bouillaguet et al.[11]

AH-Plus (Group I), although had good adaptation at dentin-sealer interface [Table 2], showed significantly higher ($P < 0.05$) mean average gap at core-sealer interface compared to GuttaFlow and RealSeal. Greater gap at core-sealer interface [Figure 1e and f] may be attributable to lack of bonding between AH-Plus and gutta-percha,[11,22] and linear setting shrinkage of 0.033% ± 0.01% in AH-Plus.[23] Better adaptation between the dentin and AH-Plus but little adaptation between gutta-percha point and AH-Plus has been also seen in studies of Bouillaguet et al.[11] and Tay et al.[24]

CONCLUSION

Under the parameters and limitations of the present study, it can be concluded that GuttaFlow is better adapted than RealSeal and AH-Plus to core obturating material as well as to dentin (discussed in Part I) in the apical third of root canals and thus may be the preferred sealer among the three to be used in clinical practice.

Nevertheless, results of this in vitro study need to be confirmed through further in vitro, 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 SEM 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.[24]

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Conflicts of interest

There are no conflicts of interest.

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