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Comparative assessment of apical sealing ability of three different endodontic sealers: A scanning electron microscopic study

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ABSTRACT

Aim: The present in vitro SEM study compared the apical sealing ability of three different endodontic sealers used in single cone obturation technique.

Material and method: 45 freshly extracted mandibular premolars with single canal and fully formed apices were selected. The samples were decoronated at/below the cementoenamel junction (CEJ) obtaining root lengths of 15 mm. The samples were instrumented using ProTaper rotary file system SX-F2. Following instrumentation the samples were randomly divided in three different groups for three different sealers to be used in single cone obturation technique. Group 1 EndoSequence BC, Group 2 GuttaFlow 2 and Group 3 AH Plus. The sealers were allowed to set completely. Following this the samples were longitudinally sectioned at the apical third and gold sputtered for SEM evaluation. The interphase between the radicular dentin and the root canal filling material were obtained in micrometers (μm) from the SEM images. Statistical analysis was performed.

Results: The groups exhibited a statistically significant difference ($p < 0.01$). Group 3 presented with the highest interphase distance ($p < 0.01$), whereas Group 1 and 2 exhibited a statistically similar values ($p > 0.05$).

Conclusion: The GuttaFlow 2 and Endosequence BC endodontic sealers showed better adaptation to the radicular dentin as compared to AH Plus sealer.

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1. Introduction

The hermetic sealing of the root canal by means of a three dimensional obturation of the entire pulp canal space is the factor governing success of an endodontic treatment. Ingress of tissue fluids, bacteria and their by-products from the oral cavity and/or the periapical region into the pulp canal space may result in re-infection and subsequent failure of endodontic treatment.[1] Also, micro-organisms may remain active in the dentinal tubules even after meticulous shaping and cleaning of the radicular space. Thus a perfect seal of the root canal space is mandatory to prevent the bacteria and their endotoxins from reaching the root apex and also to inhibit their entry from the apex.[2]

Different techniques and materials have been developed to obtain a hermetic seal. Among the materials currently used, gutta-percha is known to have good physical and biological properties, however it also have unfavorable characteristics such as low flow and low adhesion and hence it is used with an endodontic sealer.[3,4] The use of sealers alongside gutta-percha helps to produce a more homogeneous filling, aiding

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in a desired seal.[3,5] The use of sealer is critical since the infiltration of fluids into the filling may occur at the interfaces of the sealer with dentin surface, sealer with gutta-percha, inside the sealer or by the dissolution of the sealer.[3,5,6]

Ideally, root canal sealer should be biocompatible, antibacterial, nontoxic, radiopaque, and dimensionally stable. It should also possess the ability of good adhesion and should result in elimination of the interface between the gutta-percha and the dentinal walls entirely.[7]

Harnessing the development in endodontics, several evolutions in endodontic sealers have taken place, which compensate for the drawbacks of predecessors.

GuttaFlow 2 (Coltene Whaledent, GmBH + Co.KG, Langenau, Switzerland) a novel root canal filling material contains gutta-percha particles in powder form and sealer (polydimethylsiloxane) combined. This material exhibits a 0.2% expansion on setting, enhancing its adaptation to radicular dentin.[8]

Recently, a new root canal sealer, EndoSequence BC sealer (Brasseler, Savannah, GA, USA), has been introduced that successfully results in hydroxyapatite formation during the setting process, ultimately creating a chemical bond between radicular dentin and the sealer.[9–11] It is supplied as a premixed, ready-to-use injectable white hydraulic cement paste.

Hence the present study was formulated with the aim to assess the adaptation of Guttaflow 2 (silicone based), Endosequence BC sealer (bioceramic based) and AH Plus (epoxy-resin based) sealers to the radicular dentin at the apical third using scanning electron microscopy.

2. Materials and methods

45 freshly extracted human mandibular premolars with single canal and fully formed apices were acquired from a pool of orthodontically extracted teeth. The teeth were decoronated to achieve an approximate root length of 15 mm, using a low-speed diamond disc under water cooling. A size #10 K-file was inserted in the root canal until it was just visible at the apical foramen. The root canals were prepared 1 mm short of this length first by creating a glide path till #20 K-file followed by full sequence of Protaper (Dentsply Maillefer, Ballaigues, Switzerland) rotary instrumentation SX-F2. After each instrument, the canals were irrigated with 2 ml 5% sodium hypochlorite (NaOCl) and Ethylenediaminetetraacetic acid gel (EDTA, RC Help, Prime Dental, India) was used as a lubricant throughout the procedure. After complete instrumentation, all samples were rinsed with 5 ml 5% NaOCl (1 min), and then flushed with 5 ml 17% Ethylenediaminetetraacetic acid (EDTA; Dent Wash, Prime Dental, India) (1 min) and finally with saline solution. Following the completion of the above procedure, canals were dried using sterile paper points and the samples were randomly divided in three groups ($n = 15$) for single cone obturation technique using three different sealers (EndoSequence BC, GuttaFlow 2 and AH Plus).

2.1. Group 1 (gutta-percha + EndoSequence BC)

A standard 25/0.6 (Dentsply Maillefer, Ballaigues, VD, Switzerland) mastercone was selected and confirmed using a radiovisiography (RVG). In this group EndoSequence BC (Brasseler, Savannah, GA, USA) was used as a sealer. The premixed sealer available in syringe form was placed into the root canal using a dispensing tip. Some of it was dispensed on the mixing paper pad and the mastercone was coated with the sealer and introduced apically into the canal. The excess cone was seared off using a hot hand plugger as the obturation was to be carried out using single cone technique.

2.2. Group 2 (gutta-percha + GuttaFlow 2)

The mastercone was selected as in group 1 to be used with GuttaFlow 2 (Coltene Whaledent, GmBH + Co KG, Langenau, Switzerland). The sealer in a double barrel syringe form was placed into the root canal using a dispensing tip. Some of it was dispensed on the mixing paper pad and the mastercone was coated with the sealer and introduced apically into the canal. The obturation was completed as in group 1.

2.3. Group 3 (gutta-percha + AH Plus)

The mastercone was selected as in group 1 to be used with AH Plus (Dentsply DeTrey, Konstanz, Germany) as sealer. AH Plus sealer was mixed in equal volumes (1:1) of Paste A (Epoxide paste) and Paste B (Amine paste) on a mixing pad to a homogenous consistency. The sealer was placed in the canal using a lentulo spiral after which the mastercone was coated with the sealer and introduced apically into the canal, and the obturation was completed as in group 1.

The teeth were the stored in 100% humidity at 37 °C for 72 h to allow the sealer to set completely. For Scanning Electron Microscopy (SEM) analysis, the apical 1/3rd of each root was abraded using a diamond disc coupled to a low-speed handpiece until the obturating material is exposed. Care was taken that the obturating material was not displaced (Fig. 1a–c).

The images acquired after SEM analysis of all the samples were assessed by inbuilt software and the distance from the radicular dentin to the root canal fillings was measured in micrometers (μm) (Fig. 2a–c).

The statistical analysis was performed with the values of the samples in all the three groups using SPSS software v16.

3. Results

The mean distance between the radicular dentin and the root canal filling exhibited by the three groups were; group 1 (gutta-percha + EndoSequence BC) 5.241 ± 0.17 μm, group 2 (gutta-percha + GuttaFlow 2) 4.975 ± 0.35 μm and group 3 (gutta-percha + AH Plus) 15.065 ± 1.01 μm. The groups exhibited a statistically significant difference ($p < 0.01$) (ANOVA, SPSS software v16). The post-hoc test revealed that group 3 (gutta-percha + AH Plus) presented with the highest difference between the three groups ($p < 0.01$) whereas group 1 and 2 exhibited a statistically similar values ($p > 0.05$) (Table 1). The meanwise distribution of the samples for the three groups has been plotted in Graph 1.

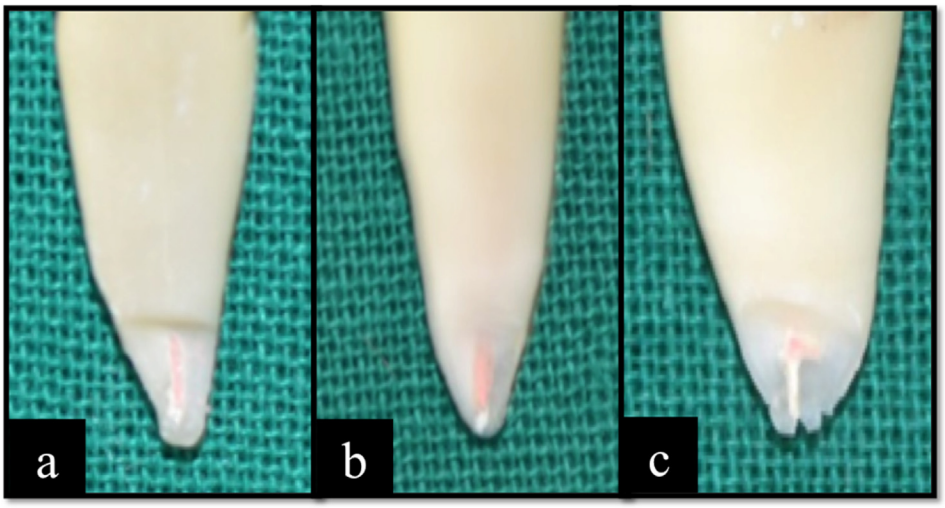


Fig. 1 – Apical sectioning of the samples for SEM evaluation. a. EndodSequence BC, b. GuttaFlow 2, c. AH Plus.

4. Discussion

The apical sealing remains relatively vulnerable to microbial leakage as compared to the coronal seal.[12] Hence the current study was carried out focusing on the ability of three different endodontic sealers to successfully seal the apex by single cone obturation technique using gutta-percha.[13] Also, apical leakage jeopardizes the biological response to endodontic sealers because it facilitates the release of unreacted components from materials directly into the periapical tissues.[14]

Various methods have been used and reported in literature, evaluating the apical sealing ability of various root canal filling materials. Examples of such methods are dye penetration test,[15,16] fluid filtration methods,[17] radioactive isotope studies, electrochemical leakage tests, bacterial penetration test[18] and scanning electronic microscopic analysis.[19,20]

Scanning electron microscope was used in the study to assess the adaptation of sealer to the radicular dentin because it has large depth of field, higher resolution and better magnification at the interface. The SEM uses electromagnets rather than lenses allowing the researcher to have more control over the degree of magnification, thereby providing strikingly clear images.[21]

According to the SEM findings of the present study, the samples obturated with GuttaFlow 2 and EndoSequence BC sealer when used in single cone obturation with gutta-

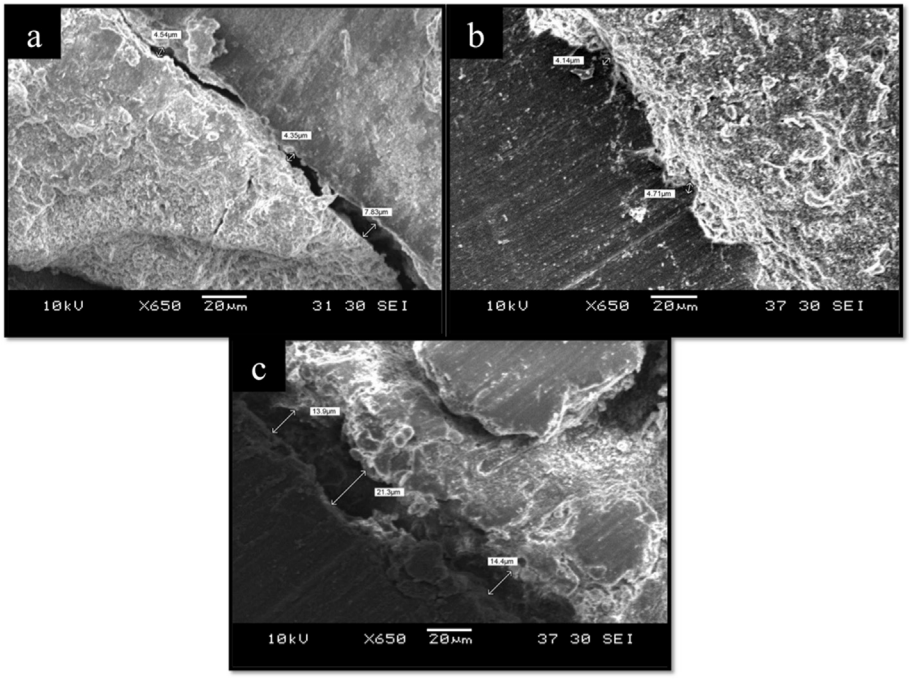


Fig. 2 – Acquired SEM images of the samples at 650× magnification. a. EndodSequence BC, b. GuttaFlow 2, c. AH Plus.

Table 1 – Mean, minimum, maximum, standard deviation, *p* values and post-hoc test of the distance from the apical radicular dentin to the root canal filling for the three groups.

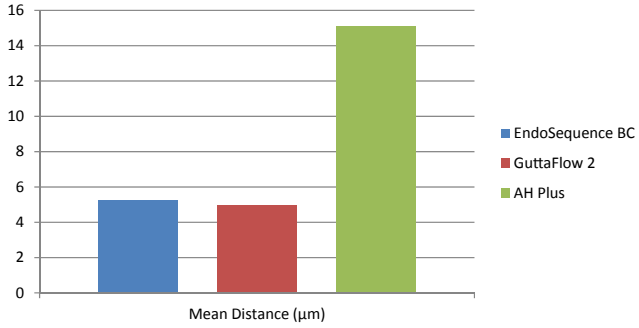
Distance (μm)	EndoSequence BC	GuttaFlow 2	AH Plus
Mean	5.241	4.975	15.065
Minimum	5.03	4.03	13.90
Maximum	5.57	5.50	16.53
Standard deviation	0.17	0.35	1.01
p Value	<0.001	<0.001	<0.001
Post-hoc Test	1 < 3, 1 ≅ 2	2 < 3, 2 ≅ 1	3 > 1, 2

percha,[13] showed good adhesion to the dentine walls, with a tight sealer-dentin interface, when compared to AH Plus sealer.

GuttaFlow 2 is a novel root canal filling material that combines two products in one. It contains gutta-percha particles in powder form, with particle size of less than 30 μm, and sealer (polydimethylsiloxane).

As a silicone based sealer, it has a homogeneous structure with particles of gutta-percha and appears to fill the dentinal tubules with intimate adaptation to the canal walls (Fig. 2b). In addition, as no heat was used with placement of the material (warm lateral compaction/thermoplastic technique), no shrinkage might have occurred. More advantageous is the manufactures claim of 0.2% expansion of the material on setting, helping it to adapt more closely to both the gutta-percha and radicular dentin, resulting in enhanced sealer flow and adhesion against the dentinal tubule walls.[8]

Endosequence BC sealer is a highly biocompatible, hydrophilic, premixed calcium silicate cement that utilizes the inherent moisture in dentinal tubules to initiate its setting reaction. Dentin is composed of approximately 20% (by volume) of water and EndoSequence BC sealer uses this water to initiate and complete its setting reaction.[11] This sealer forms hydroxyapatite upon setting and readily bonds to root canal dentin. The equally good sealing ability exhibited by Endosequence BC sealer can be attributed to its low particle size, hydrophilicity and low contact angle which enables the cement to spread easily over the radicular dentin and enter the lateral microcanals. In addition, it also has a significant expansion of 0.20%.[22] These features lead to the formation of a gap free chemical bond between the sealer and the dentinal walls that makes it an effective sealer. Additional advantage is that it exhibits potent antimicrobial action, excellent biocompatibility, significant stimulation of periodontal regeneration and is osteoconductive.



Graph 1 – Meanwise distribution of the distance from the radicular dentin to the root canal filling for the three groups.

From the results of the present study, AH Plus (epoxy-resin), exhibited greater marginal gap between the radicular dentin and the root canal filling interphase when compared to GuttaFlow 2 (silicone based) and Endosequence BC (bioceramic based) sealers. This might be due, the fast setting and subsequent polymerization shrinkage of AH Plus sealer,[23] the low penetration ability of this sealer within the dentinal tubules[24] and its hydrophobic property that prevents good adaptation to the incompletely dried canal,[25] as reported in literature.

The results obtained from the present study are in accordance with numerous in vitro studies by De-Deus et al,[24] Mohamed Abdel Aziz Mohamed El Sayed et al,[26] Savariz et al,[27] Eldeniz et al,[28] concluding the higher apical sealing ability of GuttaFlow when compared to AH Plus.

In the current study instead of GuttaFlow, an advanced variant GuttaFlow 2 was used. Basically, these differ in the form of silver particle used. GuttaFlow and GuttaFlow 2 incorporate nanosilver and microsilver, respectively, as the antibacterial component.[8]

Our results are also in accordance with those of Setia et al,[7] who in an in vitro study demonstrated better sealing ability of bioceramic based sealers.

5. Conclusion

Based on the results of this study it can be concluded that GuttaFlow 2 and Endosequence BC sealers exhibited a comparatively similar adhesion when compared to AH Plus which exhibited the least adhesion and maximum gap at the radicular dentin and root canal filling interphase. In the present study only the apical sealing ability was addressed when the sealers were used in single cone obturation technique with master gutta-percha cone. However, before any definite conclusion can be drawn further studies should be encouraged to evaluate the apical sealing ability of these sealers.

Conflicts of interest

All authors have none to declare.

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