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Comparative Assessment of Root Canal Sealer's Apical Sealing Ability

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Abstract

Aims: To compare the apical sealing ability of TotalFill BC, AH Plus Jet, and GuttaFlow Bioseal sealers. **Materials and Methods**: Thirty single rooted mandibular premolars were decoronated and standardized at 15mm. The specimens were chemo- mechanically prepared, and randomized into three experimental groups (n =10) according to the root canal sealer tested: TotalFill BC, AH Plus Jet and, GuttaFlow Bioseal. The specimens were filled using single cone technique. The specimens were decalcified, dehydrated, and cleared. The specimens were analyzed by stereomicroscope, and digital images were captured using stereomicroscope attached camera. The apical dye leakage depth was measured and evaluated using four grade scoring system at 10X magnification. The apical micro leakage data among experimental groups were statistically analyzed by one way analysis of variance (ANOVA) test and Fisher's exact test at 5% significance. **Results**: Statistically, there was no significant difference in apical micro leakage among the experimental root canal sealers. (P>.05) **Conclusions**: In this study, no experimented root canal sealer had perfect sealing ability. The experimental root canal sealers were similar in their sealing ability at apical area of root canal.

الخلاصة

الأهداف: الأهداف: لمقارنة قدرة السداد القمي لموانع التسرب التالية (GuttaFlow ¸ AH Plus Jet ¸ TotalFill BC) Bioseal **المواد وطرائق العمل**: تم استعمال وتوحيد ثلاثين اسنان ضواحك سفلية ذات جذر واحد عند ١٥ ملم. حضرت العينات كيميائيًا و ميكانيكيًا. قسمت العينات بشكل عشوائي إلى ثلاث مجموعات تجريبية وفقًا لسداد قناة الجذر التي تم اختبارها. تم ملء العينات باستخدام تقنية المخروط الفردي. انتزع الكلس من العينات وتجفيفها وتطهيرها. تحليل العينات بواسطة مجهر مجسم وتم التقاط الصور الرقمية باستخدام كاميرا رقمية متصلة. قياس عمق تسرب الصبغة القمي وتقييمها باستخدام أربعة درجات في التقييم ذات قوة تكبير(١٠) درجة. حللت بيانات التسرب الجزئي القمي بين المجموعات التجريبية إحصائيًا عن طريق تحليل التباين أحادي الاتجاه واختبار فيشر الدقيق بدلالة ٥٪. **النتائج**: لا يوجد إحصائياً فرق معنوي في التسرب المجهري القمي بين سدادات قناة الجذر التجريبية. **الاستنتاجات**: في هذه الدراسة عدم وجود مادة سدادة قناة الجذر ذات قدرة إحكام مثالية. كانت سدادات قناة الجذر التجريبية متشابهة في قدرتها على الختم في المنطقة القمية لقناة الجذر.

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INTRODUCTION

The crucial goal of endodontic treatment is to preserve the health of the apical and periapical tissues; and prevents recontamination of the root filled canal [1] which can be successfully established on triad of chemo mechanical

preparation; and tri dimensional filling of root canal system [2]

It has been suggested by Ingle *et al*.[3] in "Washington study" that apical percolation of periapical exudate into the incompletely filled root canal space; accounted for about 60% of root canal treatment failure.

Root canal sealer should precisely seal the root canal laterally and apically; achieving good adaptation to radicular dentin and fill the voids and irregularities[4] .Hence, root canal sealer contributes to the formation of a strong single cohesive bonding[5] between the dentinal tubules of root canal wall and gutta-percha by achieving monoblock bonding[6].These properties are desirable requirement that strengthen and prolong the clinical longevity of the root filled tooth as a result of providing a fluid impervious seal[7]

Monoblock bonding is beneficial outcome that increases the sealing ability due to avoidance of undesirable gaps formation [6]; and prevent residual bacteria from recontamination of the root canal system [1] Otherwise, gaps favor leakage resulting in recontamination and failure of the endodontic treatment [8]

Epoxy resin sealers are widely used and AH Plus has been considered the gold standard root canal sealer. But, it still has limitations, including mutagenicity, inflammatory reaction and hydrophobicity in addition to advantages of calcium silicate sealers including stability, biocompatibility and hydrophilicity [9] .

The hydrophilic environment in root canal system, water resorption, and solubility of root canal sealers are important factors contributing to affect sealing ability of epoxy resin; and calcium silicate-based sealers [9]

Hence, the aim of this study is to compare the apical sealing ability of TotalFill BC, AH Plus Jet and GuttaFlow Bioseal sealers

The null hypothesis of this study assumed that there should be no difference in sealing ability among the experimental root canal sealers.

MATERIALS AMD METHODS

This study was approved by the Scientific Research Committee / Department of Conservative Dentistry / College of Dentistry / University of Mosul.

Selection of Teeth

Thirty human mandibular premolars were used as study specimens; and immersed in a 0.1% thymol solution at room temperature until the time of the experiment [10].

Preoperative periapical radiograph (Carestream, USA) was taken for each tooth to confirm the presence of a single straight un manipulated root canal; and exclude those with previous endodontic treatment, calcification and internal resorption [11].

The teeth were decoronated at/below the cemento enamel junction (CEJ) with a diamond fissure bur; under continuous water cooling [12] to standardize root length of 15 mm, which had been measured using digital caliper[2].

Preparation of Specimens

The specimens were accessed and a size 10 K-file (Dentsply Maillefer ,Switzerland) was inserted into each root canal until it was just visible at the apical foramen ;the length of K-file was measured as well as working length was confirmed by subtracting 1 mm from this length[13] .

The instrumentation procedure was performed using the crown down technique with Protaper Next rotary system nickel-titanium files (Dentsply Maillefer ,Switzerland) in a sequential order (X1-X2)[14] .

The irrigation protocol had been done as :2 ml of 5% sodium hypochlorite (NaOCl) (CHLORAXID, ul. Kwiatkowskiego) was used as irrigtant and 17% ethylene diamine tetra acetic acid gel (EDTA) (Dentsply Maillefer ,Switzerland) was used as a lubricant during the instrumentation procedure[14].After instrumentation procedure, all specimens were rinsed with 5ml of 5% NaOCl for 1 min , 5ml of distilled water for 1 min, 5ml of 17% EDTA for 1 min and finally with 5ml of distilled water for1min[15].

Specimens Grouping and Root Canal Filling

The specimens were randomly divided into three experimental groups: (n =10) according to the root canal sealer tested (TotalFill BC, GuttaFlow Bioseal, and AH Plus Jet); the experimental sealers were handled according to manufacturer's instructions, and filled by single cone technique. The master cone X2 was coated with the sealer, and inserted in to canal to full working length; excess gutta-percha cone was cut off from the canal orifice using a heated condenser instrument; after completion of filling procedure. Then, the specimens were stored in sterile container in 100% humidity for 72 hours at 37 C to allow complete setting of root canal sealer [16].

Apical Leakage Test

A coat of nail polish (FloDerm,P.R.C) was applied on the outer surface of each specimen except the apical area ;about 1mm free from nail paint . After one hour period, a second coat of nail paint was applied. Once the second coat had been completely dried, the specimens were immersed in a 2% methylene blue dye solution for 48 hours. Then, the specimens were removed, and washed under running tap water, and were allowed for dryness to easy scrape the nail paint from the outer surface by a scalpel instrument [17].

Clearing Technique

This technique was performed by following steps. First step, was decalcification process by submerging specimens into 5% nitric acid for 4days, the acid was changed every day, shaken three times in a day [18]. On 4th day, the specimens were examined by trying to thrust a thin needle through the cervical part. If the needle went easily through. Therefore, the specimens were soft and ready for the next step so the specimens were washed under running water for 4 hours[18]. The next step, was dehydration process by submerging the specimens in 80% ethyl alcohol for 12 hours ,90% ethyl alcohol for 6 hours, and finally in 100% ethyl alcohol for 3 hours which was renewed every hour of these 3 hours [18].The final step, was transparency by submerging the specimens in 100% methyl salicylate for 2 hours until the specimens made transparent at that time, the specimens were ready to be evaluated and studied[19] .

Stereomicroscopic Observation

All the specimens were viewed under stereomicroscope (OPTIKA, Italy) at10X magnification (Figure 1) by blinded examiner. Stereomicroscope was calibrated prior to observation, digital images of specimens had been captured using attached camera(OptikamB5, Italy) on a stereomicroscope[19] ,linear dye penetration leakage from root apex to the most coronal extent of dye penetration was measured in millimeters, and scored by scoring system[20] .Dye apical leakage was scored :Score 0: if there was no leakage, score 1: if leakage was less than or equal 0.5 mm, score 2: if leakage was from 0.51mm to less than 1 mm and score 3: if leakage was more than 1 mm[14].

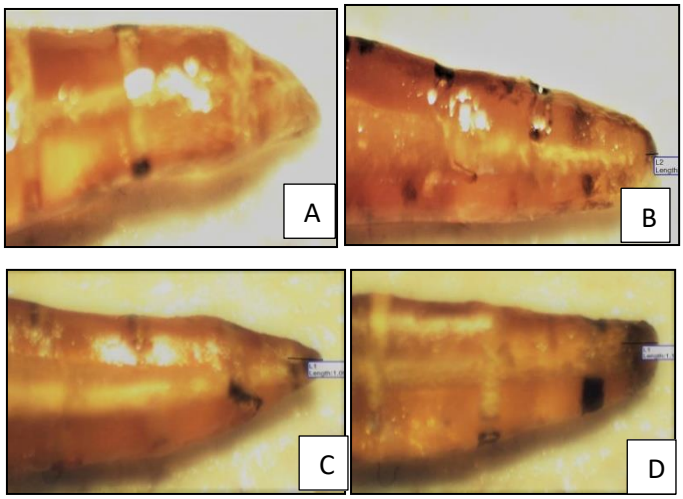

Figure 1: Dye apical leakage score. (A) score 0:no leakage; (B) score 1: leakage ≤0.5 mm; (C) score 2: leakage (0.51 – 1) mm; (D) score 3: leakage >1 mm.

Statistical Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS, version 25). Shapiro-Wilk test was used to test the normality of the data. One way analysis of variance (ANOVA) test was used to compare means of apical micro leakage value among experimental root canal sealers. Fisher's exact test was used to compare the percentage of distribution among apical micro leakage scores at 5% significance level ($p < .05$).

RESULTS

It was evident in Table 1 and Figure 2 that, the highest mean apical micro leakage was observed on AH Plus Jet sealer (1.290) mm, whereas the least mean apical micro leakage was observed on GuttaFlow Bioseal sealer (0.670)mm, ANOVA test showed that, no significant difference was observed in apical micro leakage among experimental root canal sealers; indicating that, experimental root canal sealers had comparable sealing ability ($p>0.05$).

It was evident in Table 2 that, all the experimental root canal sealers showed apical micro leakage but in various distributions, the highest distribution of apical micro leakage scoring was observed on AH Plus Jet sealer on score 3; which was 70.0%, whereas the least distribution of apical micro leakage scoring was observed together on AH Plus Jet sealer, and TotalFill BC sealer on score1, which was 10.0%. All experimental root canals showed no apical micro leakage, but in different distributions which were 3 specimens (30.0%) on GuttaFlow Bioseal sealer; and both TotalFill BC sealer, and AH Plus Jet sealer were 2 specimens (20.0%).

Table 1: Mean apical micro leakage of experimental root canal sealers

	N	Mean leakage (mm)	(±SD)	P
Bio	10	0.800	(±0.51)	
AH	10	1.290	(±0.89)	0.140
GF	10	0.670	(±0.66)	
Total	30	0.920	(±0.73)	

*By ANOVA test.

Table 2: Analysis of the apical micro leakage scoring distribution

	Bio		AH		GF	
Score	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**
0	2	(20.0)	2	(20.0)	3	(30.0)
1	1	(10.0)	1	(10.0)	2	(20.0)
2	3	(30.0)	0	(0.0)	2	(20.0)
3	4	(40.0)	7	(70.0)	3	(30.0)
Total	10	(100.0)	10	(100.0)	10	(100.0)

*By Fisher's exact test.

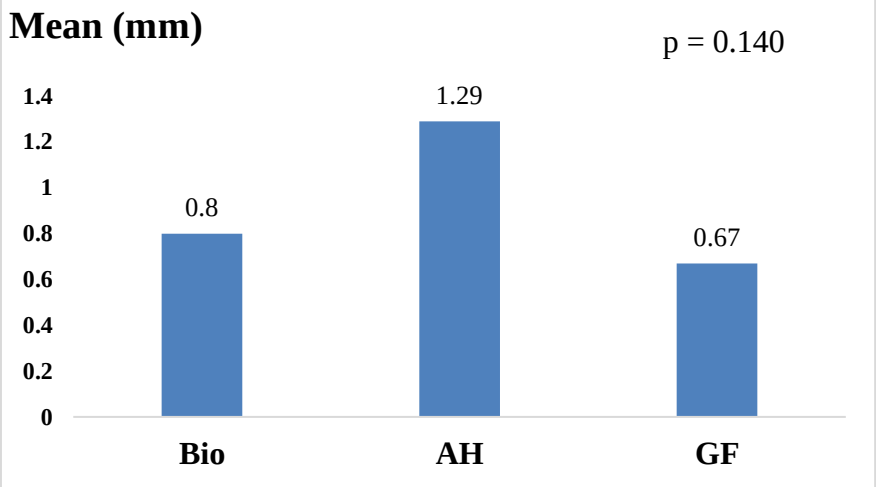

Figure 2: Column graph of mean apical micro leakage of experimental root canal sealers.

DISCUSSION

Achieving a fluid impervious seal is an important factor for successful root canal fillings [(21)]; since the root canal fillings would influenced by gaps that alter their sealing ability [(22)]; because gaps would be connected to create a sort of complex fine network inside the filled root canal that affects the tridimensional morphology of the root canal filling[(23)].

The apical third of the root canal system is very complex, difficult to clean, and has a vast anatomy variation. Hence, high risk of micro leakage[(24)].

There is no standard technique used to measure the sealing ability, root canal filling materials are often compared by bond strength test, and micro leakage test[(25)].

In general, various recognized techniques are used to evaluate micro leakage with different outcomes: Dye penetration, bacterial penetration, fluid transport, clearing technique [(26)], scanning electron microscope(SEM), and micro-computed tomography (μCT)[(27)].

In this study, dye penetration technique is used because it is one of the most widely used for micro leakage evaluation of root canal fillings; since it is simple, fast, no need for sophisticated equipment [(28)], and offer a realistic imitation of clinical condition[(29)] .

Methylene blue dye is precisely used in this study to assess the depth of dye penetration by linear measurement; since it has low molecular weight less than molecular weight of bacterial toxins; so penetrates deeply along the root canal filling materials, handling is easy and fast, inexpensive, high staining amount and does not absorbed by dentine hard tissue[(30)] .

To assess the depth of dye penetration, clearing technique is used in this study because this technique provides

three dimensional illustration of the dye penetration ;and achieves good transparency without eliminating the tooth substance .Thus, making it better in leakage assessment than longitudinal cutting technique [31] ,which has a low probability of cutting through the deepest level of the dye penetration leakage; because the selection of cutting axis is random [32] ,or the transverse cutting technique in which the dye penetration leakage level cannot be determined ;and only can determin e if there is leakage or not[31] .

In this study, the highest distribution of apical micro leakage scoring is observed on AH Plus Jet sealer(70.0%) ,which could be attributed to an early inadequate bonding between this sealer, and dentinal walls because this sealer has fast polymerization reaction ,hydrophobic in nature ,and subsequently shrinkage during early stage of polymerization reaction ;so gap would be formed. Hence, high risk of leakage[33] .Also, this sealer consists from large sized particles (1.5-8) µm which could not easily penetrate into small dentinal tubules particularly at the apical area[34].

In this study, the least micro leakage means is observed on GuttaFlow Bioseal sealer(0.670)mm ,which could be attributed to high flow rate , high water sorption , hydrophilic in nature [35] , low surface tension, and volumetric expansion changes on setting reaction (0.2–0.6)% [36] .In addition to that, mineralization ability on setting because of bioactive glass component[37].

In this study, no statistically significant differences are among apical micro leakage of TotalFill BC, AH Plus Jet, and GuttaFlow Bioseal sealers (p >.05), which could be attributed to different factors as physical properties and, the bonding ability to achieve monoblock with the dentinal tubules [14].

Osiri *et al*.[38] showed that, the tubular penetration of root canal sealer has the benefit of enhancing the mechanical bonding of sealer to the dentinal walls ;since the tubular penetration of root canal sealer will act as a physical barrier to avoid micro leakage of root canal system.

The experimental root canal sealers had different bonding mechanism, and different penetration ability in dentinal tubules. TotalFill BC sealer is able to bond mechanically, and chemically with the dentinal tubules; as this sealer consists from Nano size particles along with good flow property, low contact angle, hydrophilic in nature that increases the ability to penetrate in dentinal tubules[39] with the production of hydroxyapatite on complete setting[40].

AH Plus Jet sealer has good physical properties including slightly thixotropic, long setting time ,dimensional stability, and low shrinkage on complete setting that increases the ability to penetrate in dentinal tubules[41] ;and

produces rigid and strong polymer with collagens of dentin through mechanical bonding because of creep capacity[42] .

GuttaFlow Bioseal sealer was able to bond mechanically, and physically with the dentinal tubules[14] ;as this sealer consists from Nano sized gutta-percha particles ,which was similar to the core base material (gutta-percha) along with thixotropic property[43] ;and setting expansion that increases the ability to penetrate in dentinal tubules [25].

The result of this study in conformance with Zhang *et al.* [44] who, studied the sealing ability and showed that, iRoot SP sealer was comparable to AH Plus sealer and Ersahan and Aydin,[45] had found that no difference between AH Plus and iRoot SP in terms of apical sealing ability.

Also, Ebert *et al*.[46] showed that GuttaFlow,GuttaFlow2 ,and AH Plus sealers exhibited similar dye apical leakage values and Amanda *et al*.[14] showed that Bioceramic sealer and GuttaFlow Bioseal sealer showed similar apical leakage values.

In contrast, Shinde *etal*. [16] indicated that the adaptation of GuttaFlow 2, and Endosequence BC sealers were better than AH Plus sealer to the root dentin. Also, Asawaworarit *etal*. [47] showed that EndoSequence BC sealer had better sealing ability and penetration ability than AH Plus sealer.

CONCLUSION

The tested root canal sealers have displayed good sealing ability, but none of them are perfect. TotalFill BC, AH Plus Jet and GuttaFlow Bioseal sealers have comparable sealing ability at apical area since, there are no significant differences among them in term of apical micro leakage.

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