

Sealing Ability of Various Types of Root Canal Sealers at Different Levels of Remaining Gutta Percha After Post Space Preparation at Two Time Intervals

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ABSTRACT **Objective:** This study evaluated the apical sealing ability of various types of sealers (Sure-Seal Root, AH Plus, and GuttaFlow2) at different levels of remaining gutta percha after post space preparation at two time intervals (1 day and 1 week after obturation). **Materials and Methods:** One hundred and two single canal mandibular premolars were decoronated at the cement–enamel junction and biomechanically prepared. Twelve samples served as negative and positive controls ($n = 6$). The remaining 90 samples were distributed into three groups ($n = 30$ each), based on the used sealer for obturation with gutta percha (Sure-Seal Root, AH Plus, GuttaFlow2). Each experimental group was divided into two subgroups ($n = 15$ each), subgroup I: post space prepared 1 day after obturation and subgroup II: post space prepared 1 week after obturation. For each subgroup, the post space was prepared to a length that remained 3, 4, or 5 mm of gutta percha apically for each of five samples. Then, the dye penetration technique was used to measure the apical microleakage. Data were analyzed using “ANOVA test” and “*post hoc* Duncan’s test.” **Results:** Sure-Seal Root sealer demonstrated the best apical seal compared with other tested sealers. Post space preparation 1 day after obturation exhibited less microleakage than the group with 1 week after obturation. Additionally, 5 mm of remaining gutta percha showed superior sealing value than 3 and 4 mm. **Conclusion:** Bioceramic (Sure-Seal) sealer is the material of choice to be used when post space preparation is required. Post space preparation was preferred to be done 1 day after obturation than 1 week after obturation. Superlative apical seal was obtained with a maximum length of remaining gutta percha.

KEYWORDS: AH plus, bioceramic sealer, GuttaFlow, post space preparation, sealing ability

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INTRODUCTION

The long-term success of endodontic treatment mostly relies on maintaining the root canal system’s hermetic sealing using three-dimensional obturation.^[1] Inadequate apical sealing leads to ingress of bacteria and their byproduct or leakage of tissue fluids through the root canal system leads to re-infection and subsequently the failure of the endodontic treatment.^[2]

Teeth that have undergone endodontic management with insufficient remaining tooth structure need to use an intra-radicular post to provide retention for the core as well as to disperse the force along the root. Preparing

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the post space requires partially removing the root canal filling material^[3]; this procedure can damage the apical seal and increase the chances of microleakage.^[4] During post space preparation using the mechanical technique, the residual filling material might be displaced or vibrated or twisted leading to bacterial invasion and re-infection of the root canal.^[5]

While preparing the post space, the integrity of apical seal is related to several factors such as the length of the remaining filling material, method of gutta percha removal, time of filling material removal, and the type of root canal sealers and their setting time.^[6] Metzger *et al.*^[7] reported that sealing ability is proportionate to the remaining obturating material's length. It is widely accepted that keeping an obturating material of 5 mm in the apical part is a safe margin.^[8] In several clinical situations, it is desirable to increase the post length, but attention must be paid to the amount of obturating material removed, so that the apical sealing does not compromise.^[9] The post space may be prepared directly after obturation or later. There are varying results about the influence of post space preparation timing after obturation on the apical seal.^[10-12]

A study showed that the delayed post space preparation until 1 week caused significantly more leakage than immediate preparation,^[13] whereas another more recent study showed that immediate and delayed post space preparation produced similar degree of microleakage when the canal was filled by single cone gutta percha in conjunction with a bioceramic sealer.^[14]

Gutta percha cones along with the sealer are considered the most widely used material for obturating the root canal. The sealer is used in combination with gutta percha to attain a fluid-tight seal. Root canal sealer is needed to seal the space between the root canal wall and gutta percha; it also fills voids and irregularities present in the root, accessory, and lateral canals.^[15]

AH Plus is a sealer that is based on hydrophobic epoxy resin. It consists of two-paste system: the resin paste and amine paste. It has good properties such as low solubility and good adhesion to dentin.^[16] The original GuttaFlow sealer was modified to give GuttaFlow 2, which is a silicon-based sealer. It is available in the syringe form; it slightly expands after setting which promotes the sealing.^[17] Sure-Seal Root is a bioceramic root canal sealer; it is available in a premixed ready-to-use injectable bioactive calcium silicate paste. The bioceramic sealers are having biocompatibility and superior adhesion to dentine by the formation of hydroxyapatite. However, the main disadvantage of these materials is the difficulty to be removed from the root canal after setting.^[18]

The current study was evaluated and compared the apical sealing ability of three types of sealers (Sure-Seal Root, AH Plus, and GuttaFlow 2) at different levels of remaining gutta percha (3, 4, and 5 mm) after post space preparation at two-time intervals (1 day and 1 week after obturation).

MATERIALS AND METHODS

ETHICAL STATEMENT

The protocol of this study was scientifically approved by the Higher Scientific Researches Committee at Faculty of Dentistry, Mosul University, Iraq at clearance number (REC reference no. UoM.Dent/H.L.29/20 on December 1, 2019).

This analysis is conducted at an experimental laboratory. It was carried out at the Dental Conservative Specialist Clinic within the Faculty of Dentistry, University of Mosul, Iraq. This analysis has been conducted between January and June 2020. It comprised 102 new extracted permanent mandibular bicuspid. Excluded teeth are those with root resorption, extensive carious lesion, and incomplete root formation.

Whole samples were decoronated at the cement-enamel junction using a diamond disc to standardized root length to 12 mm; after that, the determination of the working length was done by inserting a size #15 K file (Mani Co., Tokyo, Japan) till it was just visible at the apical foramen and 1 mm was deducted from it. To prevent dehydration, the tested samples were stored in normal saline.

Biomechanical preparation was performed by a K3 NiTi rotary instrument (Sybron Endo, Glendora, China) utilizing a crown-down technique with four instruments, which were used with a contra-angle rotary handpiece at a rotational speed of 300 rpm and torque (3 Ncm) in the following sequence: 40/0.06, 35/0.06, 30/0.06, and 25/0.06. Instrumentation was performed with very light pressure up to the working length. Root canal irrigation was performed at the beginning of the instrumentation and after each instrument size with 2 mL of 2.5% sodium hypochlorite (NaOCl) for 3 min (Safe Plus, Neelkanth, India). At the end of instrumentations, 2 mL of 17% ethylenediaminetetraacetic acid (EDTA) (Dent Wash, Prime Dental Products Private Limited, India) was utilized for 3 min to remove the dentinal smear layer, and after that 3 mL of distilled water was used to remove the remaining irrigating solutions.^[19]

Of all the whole test samples, 12 teeth were split into two control groups and were divided as follows:

- Group 1 (“-ve” control; $n = 6$): every two teeth per sealer consistent with the recommendations of

each group's manufacturer and obturated utilizing "matched-taper single cone technique."

- Group 2 ("+ve" control; $n = 6$): the samples were not obturated and permitted for 100% leakage.

The 90 teeth were remaining and distributed into three experimental groups ($n = 30$ each), depending on the sealer used:

- Group 3 (T): samples within this group were obturated utilizing Sure-Seal Root sealer (Sure-endo, Sagimakgol-ro, Jungwon-gu, Seongnam-si, Korea).
- Group 4 (F): samples within this group were obturated utilizing AH Plus sealer (DeTrey Dentsply, Konstanz, Germany).
- Group 5 (Fi): samples within this group were obturated utilizing GuttaFlow2 sealer (Roeko, Coltene, Germany).

The matched-taper single cone technique was liable for obturation of the entire canal; every sealer was mixed as stated in manufacturer's instructions. By using a heated endodontic plugger, the excess of gutta percha was removed, the access cavities were sealed with wax, the quality of root canal filling was assessed by taking radiographs, and the entire samples were incubated at 37°C. The tested groups are then subdivided (" $n = 15$ ") based on the time of preparing the post space: subgroup I in which the post space was prepared on day 1 after the obturation and subgroup II in which the post space was prepared 1 week after the obturation.

Every group was further divided into three groups based on the remaining apical gutta percha's length ($n = 5$): Group A: 3 mm left apically, Group B: 4 mm left apically, and Group C: 5 mm left apically. In all groups, post space preparation was done utilizing "# 1–4 Peeso reamers" (Dentsply, Swiss). The length of peso reamers inserted inside each canal was justified using a rubber stopper and an endodontic ruler to remove the coronal portion of gutta percha, so that the residual apical length of gutta percha is 3, 4, or 5 mm according to the group.

The post space was rinsed with 2 mL of 2.5% sodium hypochlorite (NaOCl) for 3 min; after that the canal rinse with 2 mL of 17% EDTA was accomplished for 3 min and then 2 mL of distilled water was used as a final rinse to remove the remaining of irrigating solutions using 5-mL syringes and 23-G needles. In whole experimental groups, two layers of nail polish were used to cover the root surfaces excluding the apical 2 mm; additionally, two layers of nail varnish were used to cover the "–ve" control group.

After the complete dryness of nail polish, whole samples were immersed in 2% methylene blue solution (Ase

Chemical Works, India) for 24 h at room temperature. To remove excess dye from the external root surface, the teeth were washed under running tap water, and then a # 11 scalpel blade (Swann-Morton, Sheffield, UK) was used to scrape the nail varnish and allowed to dry.

Vertical sectioning of whole teeth into two halves was along their long axis using a diamond sectioning disc underwater coolant. The root canal filling material should not penetrate, additionally by levering with a spatula split the samples into two halves. A stereomicroscope at $\times 10$ magnification was used by two observers to measure the linear extent of dye penetration from the apical root ends (in mm). Finally, the data were collected and statistically analyzed by using a three-way analysis of variance (ANOVA) test and *post hoc* tests (Duncan's multiple range tests) at $P \leq 0.05$, utilizing SPSS Version 16.

RESULTS

To facilitate the revision of this study, we clarify the comparison among three experimental sealers, each subdivided into two parts according to subgroup I and subgroup II. After that test, samples were further divided into three groups, depending on the three dissimilar lengths of remaining gutta percha left apically.

The "–ve control teeth" showed no dye diffusion [Figure 1(a)], whereas the complete dye diffusion was shown in "+ve control teeth" [Figure 1(b)].

After testing the data in terms of normal distribution, it was found that all of them are normally distributed, so we resort to the ANOVA test [Table 1].

Table 2 clarifies statistical analysis utilizing the three-way ANOVA test. To clarify the existence of significant differences among entirely tested experimental groups, it revealed that there were significant differences between the groups.

Post hoc tests (Duncan's multiple range tests) were utilized to identify the group that gives the superior value of apical seal and to perform comparison between the means of experimental samples. The interaction between the treatment was 0.039, meaning that the differences were significant at the 5% probability level [Table 3 and Figure 2].

According to the current analysis, we determined that the "T" group registered the best value of apical seal among all the other experimental groups in "subgroup I and subgroup II" at $P \leq 0.05$. The data were collected and measured using a stereomicroscope [Figure 3(a)]. "Fi" and "F" showed less value of the apical seal "in all the tested groups" at $P \leq 0.05$ [Figure 3(b) and (c)].

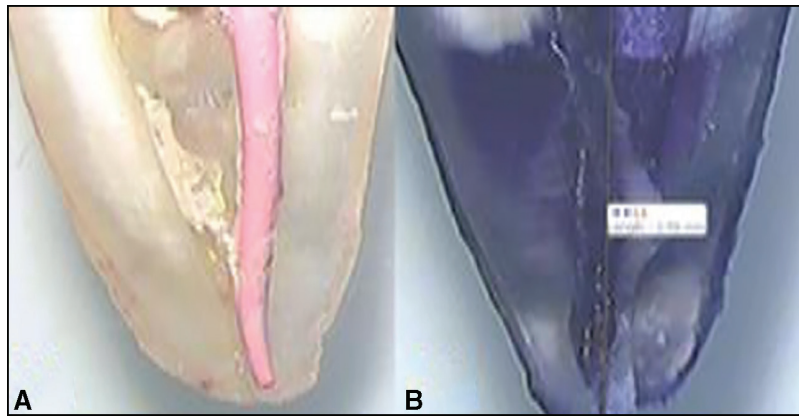


Figure 1: (a) Negative and (b) positive control groups under a stereomicroscope (10× magnification)

Table 1: Normal distribution of experimental data

			Tests of normality					
			Kolmogorov–Smirnov ^a			Shapiro–Wilk		
			Statistic	df	Sig.	Statistic	df	Sig.
1 day	3 mm	GuttaFlow 2	0.302	5	0.155	0.820	5	0.116
		AH Plus	0.167	5	0.200*	0.964	5	0.833
		Sure-Seal	0.351	5	0.044	0.783	5	0.059
	4 mm	GuttaFlow 2	0.206	5	0.200*	0.923	5	0.550
		AH Plus	0.325	5	0.091	0.889	5	0.352
		Sure-Seal	0.296	5	0.176	0.893	5	0.375
	5 mm	GuttaFlow 2	0.204	5	0.200*	0.933	5	0.618
		AH Plus	0.291	5	0.191	0.905	5	0.440
		Sure-Seal	0.325	5	0.092	0.786	5	0.063
1 week	3 mm	GuttaFlow 2	0.230	5	0.200*	0.890	5	0.358
		AH Plus	0.312	5	0.126	0.825	5	0.128
		Sure-Seal	0.293	5	0.185	0.817	5	0.111
	4 mm	GuttaFlow 2	0.269	5	0.200*	0.930	5	0.595
		AH Plus	0.214	5	0.200*	0.933	5	0.620
		Sure-Seal	0.245	5	0.200*	0.896	5	0.390
	5 mm	GuttaFlow 2	0.205	5	0.200*	0.974	5	0.899
		AH Plus	0.234	5	0.200*	0.922	5	0.543
		Sure-Seal	0.293	5	0.185	0.847	5	0.186

The result of the current study also showed that Group C gave superior value of apical seal in comparison to the other two lengths of remaining gutta percha of all experimental groups. Group B revealed superior sealing ability than group A. It reached the level of significance at $P \leq 0.05$ in groups that sealed with AH Plus and Sure-Seal after 1 week.

As a general statement, the whole reading for all the groups gives better reading at subgroup I than at subgroup II [Figure 4].

DISCUSSION

Endodontic-treated teeth often have limited support for permanent restorations. Therefore, these teeth frequently need the use of an intra-canal post to obtain retention for the core.^[20]

Gutta percha has no adaptability and adhesive ability to the root canal dentin, so it should be combined with root canal sealer. The root canal sealer should not only effectively seal the root canal system, but it must also allow removing of the gutta percha without affecting the apical seal.^[12] If leakage happens, it may occur at either the sealer–dentin wall interface or the gutta percha–sealer interface.^[11]

In the current *in-vitro* study, we analyzed the influence of both (remaining length and time of removal of gutta percha) when post space preparation was done on the apical seal using different kinds of root canal sealers. The linear measurement of the dye penetration apically and longitudinal sectioning of canals were used in the study to measure apical microleakage, as it allows the observation of the penetrated dye.^[21]

Table 2: F-test ANOVA for apical leakage at $P \leq 0.05$

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial Eta squared
Corrected model	245.854 ^a	17	14.462	73.595	0.000	0.946
Intercept	380.237	1	380.237	1.935E3	0.000	0.964
T	123.599	1	123.599	628.982	0.000	0.897
S	62.308	2	31.154	158.540	0.000	0.815
L	22.089	2	11.044	56.203	0.000	0.610
T * S	26.181	2	13.091	66.616	0.000	0.649
T * L	4.296	2	2.148	10.930	0.000	0.233
S * L	5.282	4	1.321	6.720	0.000	0.272
T * S * L	2.099	4	0.525	2.670	0.039	0.129
Error	14.148	72	0.197			
Total	640.239	90				
Corrected total	260.002	89				

T= time (1 day and 1 week); S= three different types of sealers (Sure-Seal, AH Plus, and GuttaFlow2); L = apical remaining length of gutta percha

Table 3: Apical microleakage among experimental groups (post hoc Duncan's test of experimental groups)

Time of post space preparation	Groups	Remaining length (mm)	**Mean	***N	Std. deviation
After 1 day	GuttaFlow 2	3	1.6300 ^{e*}	5	0.22394
		4	1.0340 ^{efg}	5	0.62832
		5	0.5960 ^{fg}	5	0.56664
	AH Plus	3	1.5000 ^e	5	0.27386
		4	1.0860 ^{ef}	5	0.39997
		5	0.6000 ^{fg}	5	0.60415
	Sure-Seal	3	0.6440 ^{fg}	5	0.18876
		4	0.4980 ^{fg}	5	0.18377
		5	0.3340 ^e	5	0.29151
After 1 week	GuttaFlow 2	3	5.2280 ^a	5	0.80769
		4	4.5100 ^b	5	0.47927
		5	1.5160 ^c	5	0.27428
	AH Plus	3	5.5060 ^a	5	0.36835
		4	4.1000 ^b	5	0.89443
		5	1.5320 ^c	5	0.37433
	Sure-Seal	3	3.2660 ^c	5	0.46344
		4	2.2800 ^d	5	0.75299
		5	1.0880 ^{ef}	5	0.60998

*Different letter means the presence of significant difference, whereas similar letters mean that there was no significant difference

**Mean = means of microleakage of (N) sample for every group

***N = number of samples

In the current study, a 2.0% methylene blue was used, which is frequently used in similar studies, because it is easily diffused and detected under the light; further, it is not taken up by the dentin.^[22] Whole samples were immersed in 2% methylene blue solution for 24 h because there would be enough time to provide staining if there is microleakage. Oztan *et al.*^[23] found that the immersion for more than this time might lead to an increase in the optical density of methylene blue, which means that the sealer interacts with methylene blue because of solubility of some particles in the sealers. To move out to the dye, dissolution of sealers forms a gap between the filling and the wall of root, and this might make the registered length of penetrated dye inaccurate.

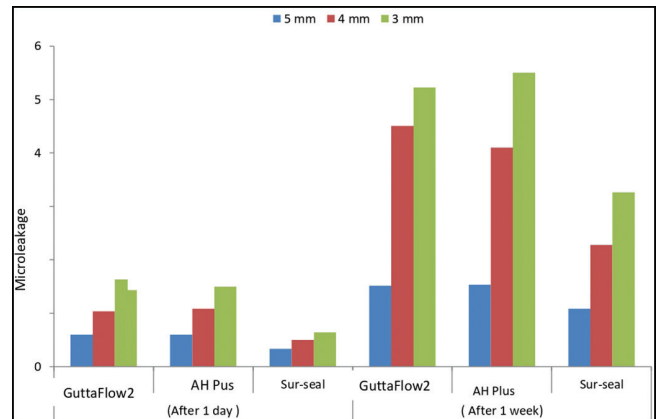


Figure 2: Histogram showing the apical microleakage among experimental groups

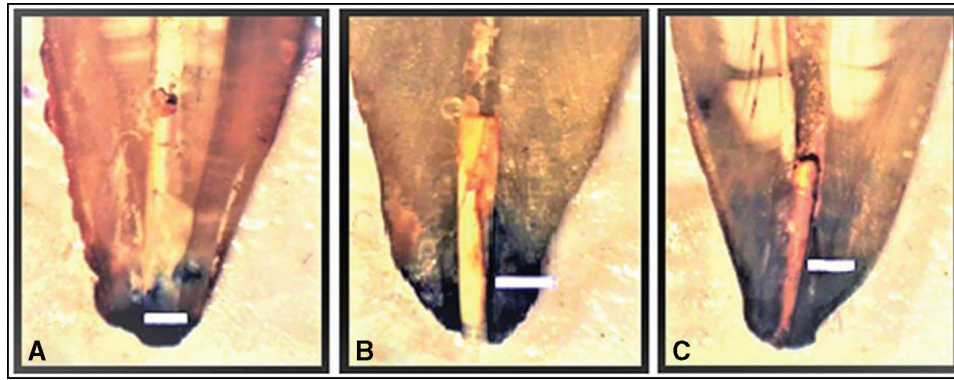


Figure 3: Apical leakage in the following: (a) Sure-Seal, (b) AH Plus, and (c) GuttaFlow 2. The whole tested specimens measured using a stereomicroscope at $\times 10$ magnification

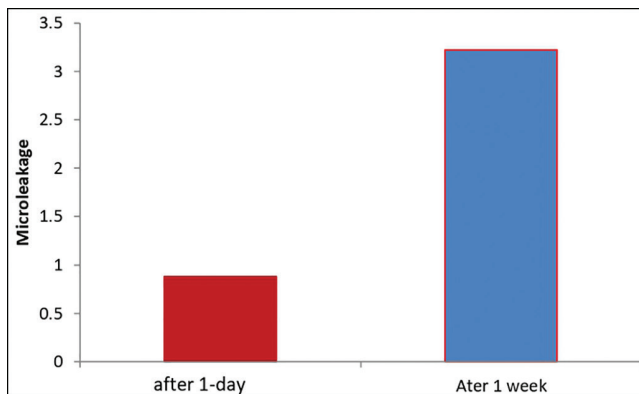


Figure 4: Histogram showing the apical microleakage in the experimental groups after 1 day and 1 week

The findings of this study showed that none of the used sealers in the study could perfectly seal the apical foramen to provide a fluid-tight seal. Group 1 failed to show any apical microleakage, and this assures the sealing ability of nail varnish and indicates that microleakage happened only via the apical foramen. Group 2 showed the highest level of dye penetration, which indicates that apical sealing capability of single cone gutta percha was deteriorated when used without root canal sealer. Among the testing group, Group T achieved the best resistance result to microleakage than Groups Fi and F.

Sure-Seal has a high ability to seal; in addition, it is a bioceramic sealer which can adapt to moisture, promote heavy penetration inside the dental tubule to create a tag, form hydroxyapatite which enhances a chemical bond with the root canal dentin, obtain a little expansion rather than shrinkage, and it has minimal film thickness. All these factors clarify its priority in sealing.^[24] This result is congruent with several previous studies. Al-Kadhi *et al.*,^[25] who compared the sealing ability of bioceramic, epoxy resin, GuttaFlow, and zinc oxide eugenol base sealers, found that the

apical leakage in bioceramic base root canal sealer was significantly lower than the other sealers and no significant differences were found between GuttaFlow and AH Plus. The result of the present study is also in agreement with the findings of Ballullaya *et al.*,^[26] who concluded that bioceramic sealers have higher sealing ability than epoxy and dye penetration method.

The results coincide with those of Asaworarit *et al.*,^[27] who compared apical leakage of bioceramic and AH Plus sealers at 1 day, 7 days, and 4 weeks using a scanning electron microscope and the fluid filtration technique and concluded that the bioceramic sealer provides better sealing ability at all times. The lower sealing ability of the epoxy resin sealer (AH Plus) may be related to the fact that its tendency to shrink while setting results in de-bonding and to disintegrate adaptation from the root canal dentin.^[27,28]

Group Fi also showed low sealing ability and many researchers explain the lack of excellent sealing ability of this material in comparison to other sealers because of inadequate wettability and low flow ability due to high surface tension and stiffer consistency of silicone, which is one of the components of GuttaFlow.^[25]

According to the outcomes of the current analysis, irrespective of the sealer type and time of post space preparation, we stated that Group C was given the superior value of apical seal in comparison to the other two lengths of remaining gutta percha for all experimental groups.

In contrast, Group A has a low scale of the apical seal. This result coincides with former studies of Rahimi *et al.*,^[29] Nixon *et al.*,^[30] and Baruah *et al.*^[31]; they found a direct relationship between the residual length of the endodontic filling material and its apical sealing efficiency. The higher microleakage at the 3-mm level might be due to the smaller diameter and fewer density

of the dentinal tubules in the apical portion of the root canal, leading to lower sealer penetration.

Delayed post space preparation “subgroup II” in all experimental groups showed significantly higher microleakage when compared with microleakage in subgroup I; this might be because when the rotary instrument was inserted into the canal to remove the gutta percha after 1 day from the obturation, the sealer may not be completely set, according to the previous study. AH Plus is not completely polymerized at 24 h, and polymerization and microhardness increased with time until the highest level is reached in 7 days.^[13] Also a study by Zeid *et al.*^[32] showed that bioceramic root canal sealers take longer time than that provided by the manufacturer to reach the final setting; the retardation in the setting of bioceramic sealer (Sure-Seal) may be due to lack of tissue fluid. In *in-vivo* conditions, the tissue fluid in the tubules of dentin could provide continual source of moistening through hydration reaction of the sealer. GuttaFlow2 may not completely set after 24 h and retains some elasticity after initial setting.^[32] In addition to that, the heat generated during the removal of gutta percha may soften this sealer because it contains gutta percha powder with particle size smaller than 30 µm. The flexibility of incompletely polymerized sealers appears to preserve the quality of the apical seal up for 24 h, in spite of the rotational force that is produced through the removal of gutta percha imparted to the area.^[33] On the contrary, during delayed post space preparation, the sealer was completely set, and the rotational forces of the peso reamer might cause movement of the gutta percha and thus break the bond at the sealer interfaces.^[12] This finding was in agreement with the results of Salim,^[34] Kala and Torvi,^[24] and Padmanabhan *et al.*^[12]

But these findings disagreed with those of Aydemir *et al.*,^[3] Al-Sabawi *et al.*,^[35] and GÜNGÖR *et al.*,^[36] which evaluated the effect of delayed and immediate preparation of post space on the apical microleakage, and their results revealed no statistically significant differences.

CONCLUSIONS

According to this study, we may conclude the following:

- The quality of the endodontic filling is very significant to prevent microleakage at the apical portion of the root canal during post space preparations. Post space preparation after 1 day causes less microleakage than the other groups (after 1 week).

- Bioceramic root canal sealer is an effective root canal sealer when post space preparation is required.
- Superlative value of apical seal is registered with the maximum length of remaining gutta percha.

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Nil.

CONFLICTS OF INTEREST

There are no conflicts of interest.

AUTHORS CONTRIBUTIONS

All the authors Wiaam M.O. AL-Ashou, Rasha M. Al-Shamaa, and Shaymaa Shakir Hassan contributed equally in the preparation of the manuscript.

ETHICAL POLICY AND INSTITUTIONAL REVIEW BOARD STATEMENT

Higher Scientific Researches Committee at Faculty of Dentistry, Mosul University, Iraq approved this study.

PATIENT DECLARATION OF CONSENT

Not applicable because it is an *in vitro* study.

DATA AVAILABILITY STATEMENT

The data of the study results are available from the author (Dr. Wiaam M.O. AL-Ashou, email: wiaamalashou@uomosul.edu.iq) on request.

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