International Journal of Medical and Health Research
ISSN: 2454-9142
Received: 04-06-2020; Accepted: 21-06-2020; Published: 08-07-2020
www.medicalsciencejournal.com
Volume 6; Issue 7; 2020; Page No. 38-45

A comparison of apical microleakage and sealer distribution of two sealers with two obturation techniques using apical dye penetration technique: An in-vitro study

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Abstract

Background: The most common cause of endodontic failures has been attributed to incomplete obturation. Bioceramic-based sealers with excellent properties are gaining popularity to fill the gap. But there is a lack of data in comparing these sealers with different obturation techniques.

Aim: To assess the apical microleakage and sealer distribution of two sealers using two obturation techniques along the root canal walls.

Materials and Methods: 80 single-rooted premolars were randomly divided into two groups for assessing the apical microleakage and sealer distribution using two different bioceramic sealers and two obturation techniques. The samples were checked for vertical dye penetration technique using 2% methylene blue dye and evaluated with a stereomicroscope at 30x magnification to study apical microleakage and sealer distribution.One way ANOVA was carried out to compare between the study groups. Statistical significance was considered at $p<0.05$.

Results: Bioroot RCS with single cone showed lesser apical microleakage when compared with BioRoot RCS with lateral condensation and MTA Fillapex sealer with single cone and MTA Fillapex and lateral condensation. On comparing the sealer distribution between the two bioceramic sealers, it was found that BioRoot RCS with single cone showed better sealer distribution than the other groups. There was a significant difference seen statistically.

Conclusions: Among the bioceramic sealers, BioRoot RCS with single cone obturation technique showed the least apical microleakage and the best sealer distribution.

Keywords: Obturation, Sealer, Apical Microleakage, Sealer distribution, BioRoot RCS, MTA Fillapex, Single cone, Cold lateral condensation, Methylene blue, Stereomicroscope

Introduction

The major aim of any endodontic obturation is to achieve three dimensional sealing of the pulp space to create a fluid-tight seal and prevent the entry of microorganisms and their toxins flow into the periapical tissues [1]. Hence, the primary purpose of the root canal sealer is to prevent periapical exudates from diffusing into the unfilled part of the canal, to avoid re-entry and colonization of bacteria and to check residual bacteria from reaching the periapical tissues.

Early endodontic research focused on the quality of endodontic treatment to ensure long-term success and the effects of microleakage on endodontic treatment outcomes. Microleakage is defined as the "diffusion of the bacteria, oral fluids, ions and molecules into the tooth and the filling material interface [2]. Many studies emphasize that the filling materials are not fixed, inert and impenetrable borders but dynamic micro crevices, which contain busy traffic of bacteria, ions and molecules [2]. This leakage may be clinically undetectable but is a major factor influencing the long-term success of endodontic therapy as it causes many severe biological effects leading to recurrence of the pathology and failure of the root canal treatment [3].

It has been reported that 59% of endodontic failures were due to leakage in the canal seal. It has been observed that microleakage between root canal filling and root canal walls may adversely affect the results of root canal treatment.[3]

The obturation of the root canal system is conducted in many ways, but the most commonly advocated method is by the application of sealer with gutta-percha as the core obturation material. According to some authors failure in endodontic therapy occurs when the apical foramen is not completely obturated or sealed [4, 5].

There has been an improvement in the formulation of the root canal sealers. The traditional zinc oxide eugenol sealers have been replaced with resin-based, silicone-based, and bioceramic-based sealers. In particular, bioceramic-based sealers are gaining popularity because of their alkaline pH, chemical stability within the biological environment, lack of shrinkage, and excellent biocompatibility [6].

The present study is about comparing two Bioceramic root canal sealers- BioRoot RCS and MTA Fillapex using single cone obturation and cold lateral condensation techniques for apical microleakage and sealer distribution using dye penetration technique.

Materials and Methods

This in-vitro study was conducted in the Department of Conservative Dentistry and Endodontics, Government Dental College and Research Institute, Bangalore.

Selection criteria

Eighty single-rooted premolars extracted freshly for orthodontic treatment purposes were obtained from the Department of Oral Maxillofacial Surgery GDCRI, Bangalore after obtaining the consent of the patient.

Inclusion criteria

Single rooted and single canal premolars, no root caries, no resorption or fracture, fully formed apices

Exclusion criteria

Mal-developed Curved roots,

Materials used

Angelus MTA Fillapex (Londrina/Parana/Brazil), Bio RootTMRCS (Septodont, Saint-Maur-des Fosses, France), Protaper rotary files F2 Guttapercha cones, Accessory cones, Paper points.

Methodology

The samples were debrided using a Hu-Friedy hand scaler and stored in normal saline solution to prevent desiccation. The access cavity was prepared and canal patency was established 1mm beyond the apex using #10K file. [7] Working lengths were established by subtracting 1 mm from the measurement obtained when a size 10 file was placed into the canal until its tip was visible under a stereomicroscope at the root apex of the samples. Canal patency was achieved by passing a flexible K file which passively moves through the apical constriction without widening the apical constriction. In this technique, the smallest diameter file is set 1 mm longer than the working length and recapitulated after each instrument to prevent the packing of debris in the apical part [8]. The working length was calculated 1mm short of apex. The canals were sequentially cleaned and shaped with Protaper (Dentsply, Maillefer) rotary files up to F2 with 17% EDTA and under constant irrigation with 3%NaOCl. The final irrigation with 5ml of Normal Saline was performed. The canals were dried with absorbent points. For examining Apical microleakage (n=40) the samples were further divided into two groups (n=20) for single cone obturation and cold lateral condensation techniques. Among the single cone obturated teeth, ten samples were obturated using the BioRoot RCS sealer and the other ten samples were obturated using MTA Fillapex sealer. Similarly, cold lateral condensation obturation was done using the same sealers after dividing the samples into two groups. The sealers were mixed as per the manufacturer's instructions and coated using lentulospiral for even distribution of the sealers along the root canal walls. The pulp chamber was cleaned and coronally sealed with a temporary restorative material.

All the teeth were stored for 48hrs at room temperature to let the sealers set. After the sealers set the four groups were coated with two layers of nail varnish except for 3mm of the root apex. Once the nail varnish had completely dried,

the samples G1 (n=40) for examining apical microleakage were immersed in 2% methylene blue solution for 24 hours at room temperature. Methylene blue penetrated along air-filled gaps by capillary action, whereas it penetrated into water-filled gaps by diffusion [9]. The teeth were then washed under running tap water to remove the excess dye on the external root surface, and the nail varnish was scraped off [10].

The sample was then vertically sectioned along the long axis to check for vertical dye penetration along the root canal from the apical region to the coronal region. This was done using a straight handpiece and diamond disc slicing the sample halfway and ten slitting the tooth using a hand instrument like a chisel. The samples were examined under a stereomicroscope (Olympus SZX16) at 30x magnification and the dye leakage was measured with a millimeter-scale from the apical constriction to the longest point of dye penetration along the canal wall and gutta-percha [11, 12]. With the help of the photomicrographs obtained, the linear measurement of the dye penetration was noted from apical to the coronal direction to nearest 0.1 mm at 30x magnification The scores were given as: Canal without dye penetration= Score 0 dye penetration ≤ 0.5mm = Score 1, dye penetration of 0.5-1mm = Score 2, dye penetration of 1-2mm = Score 3, dye penetration ≥ 2mm = Score 4, total dye penetration is Scored as 5 [12]. (fig: 1), For examining the sealer distribution G2(n=40) the samples were further divided into two groups (n=20) for single cone obturation and cold lateral condensation techniques respectively. Among the single cone obturated teeth, ten samples were obturated using the BioRoot RCS sealer and the other ten samples were obturated using MTA Fillapex sealer. Similarly, cold lateral condensation obturation was done using the same sealers after dividing the samples into two groups. The pulp chamber was cleaned and coronally sealed with a temporary restorative material all the teeth were stored for 48hrs at room temperature to let the sealers set. These samples were sectioned longitudinally at 3mm, 6mm and 9mm distance from the apex using a straight handpiece and a diamond disc and examined individually under a stereomicroscope to calculate the amount of sealer distribution [13].

Each slice was divided into 4 quadrants and examined under a stereomicroscope at 30x magnification. Sealer distribution was recorded and scored 0, 1, 2, 3 or 4 according to the amount of sealer present in each quadrant [13].

The scores were given according to the sealer per quadrant. Score 0=No loss of sealer, all the four quadrants covered with sealer; Score 1 = Loss of sealer along one quadrant but intact on the rest three quadrants; Score 2= Loss of sealer along two quadrants and intact on the two quadrants; Score 3= Loss of sealer along three quadrants and sealer present only on one quadrant; Score 4= No sealer on any quadrant seen - complete loss of sealer (fig: 2) [13, 14].

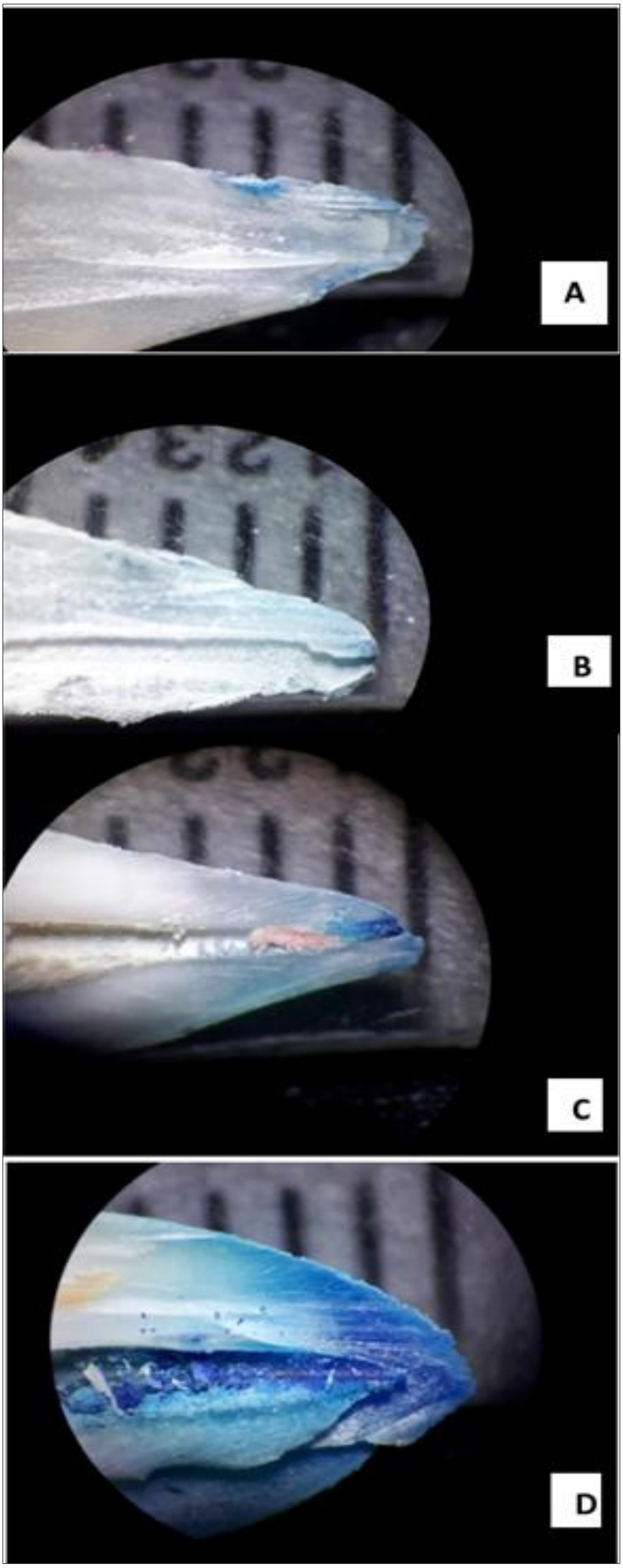

Fig 1: Vertical sections: (A) score 1 (B) score 2 (C) score 3 (D) score 4

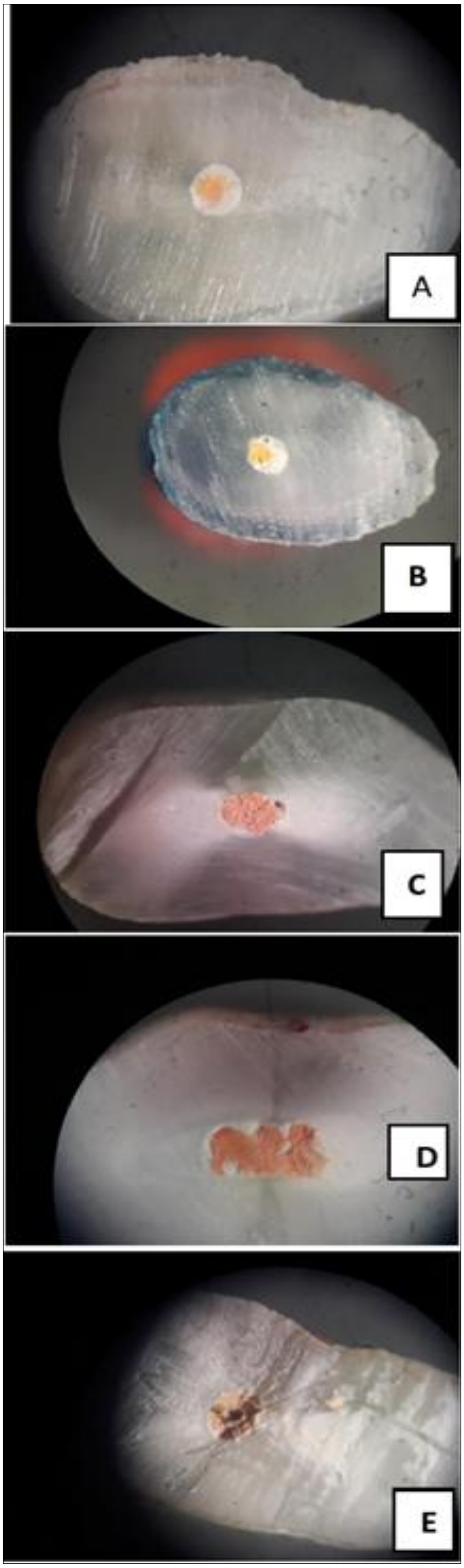

Fig 2: Horizontal sections: (A) score 1 (B) score 2 (C) score 3 (D) score 4

Statistical Analysis

The data collected were entered into Microsoft Excel spreadsheets and analyzed using the Statistical Package for Social Sciences (SPSS) version 24. Descriptive and inferential statistics were done. Quantitative data were measured through Mean and Standard Deviation. The Normality of the data was assessed using the Shapiro Wilk test. Since the data did not violate the assumption of normality in the study, Oneway ANOVA was carried out to compare the study groups. Statistical significance was considered at p<0.05(confidence interval of 95% was taken.)

Results

All the teeth showed leakage at the apical third. Among the groups on multiple comparisons for apical microleakage, there was no statistical difference in inter groups and intragroup values. Also, there was no statistical difference between the groups and within the group scores on calculating using ANOVA. (Table 1) On comparing the sealer distribution with single cone obturation and cold lateral condensation it was noted as (Table 2)

Table 1

At Different Levels of root sections	Sealer distribution AMONG GROUPS	Statistically significant difference
3mm	SC1>LC1>SC2>LC2	PRESENT
6mm	SC1>SC2>LC2LC1	PRESENT
9mm	LC1>SC1>SC2>LC2	PRESENT

Bio root RCS with Single cone = SC 1; MTA Fill apex sealer with Single cone= SC2 Bio root RCS with Lateral condensation =LC1, MTA Fill apex sealer with Lateral condensation=LC2

Table 1: Mean of values and scores of apical leakage

Groups:		N	Mean	Std. Deviation	Std. Error	P Value (ANOVA)
Values	Group1	10	1.650	0.6687	0.2115	0.572
	Group2	10	1.750	1.5679	0.4958	
	Group3	10	2.150	1.2030	0.3804	
	Group4	10	2.400	1.6964	0.5364	
	Total	40	1.988	1.3277	0.2099	
Scores	Group1	10	2.700	0.6749	0.2134	0.547
	Group2	10	2.300	1.1595	0.3667	
	Group3	10	2.900	0.9944	0.3145	
	Group4	10	2.900	1.2867	0.4069	
	Total	40	2.700	1.0427	0.1649	

Table 2: Sealer Distribution in Apical Third

APICAL THIRD	Mean	Std. Deviation	Std. Error	P Value (ANOVA)
SC1	1.100	0.8522	0.1906	0.009*
SC2	1.950	1.2344	0.2760	
LC1	1.400	0.9403	0.2103	
LC2	1.750	1.2085	0.2702	
Groups	Mean Difference (I-J)	Std. Error		P Value (Post hoc Bonferroni)
SC1 vs SC2	-.8500	0.3388		*0.003**
SC1 vs LC1	-.3000	0.3388		*0.009**
SC1 vs LC2	-.6500	0.3388		*0.006**
SC2 vs LC1	.5500	0.3388		.652
SC2 vs LC2	.2000	0.3388		*0.001**
LC1 vs LC2	-.3500	0.3388		*0.012**

Bio root RCS with Single cone = SC 1; MTA Fill apex sealer with Single cone= SC2 Bio root RCS with Lateral condensation =LC1, MTA Fill apex sealer with Lateral condensation=LC2

Table 3: Sealer Distribution between the Groups in Middle Third

MIDDLE THIRD	Mean	Std. Deviation	Std. Error	P value (ANOVA)
SC1	1.250	0.5501	0.1230	*0.006*
SC2	2.000	0.9733	0.2176	
LC1	1.350	0.7452	0.1666	
LC2	1.550	0.5871	0.1313	
Groups	Mean Difference (I-J)	Std. Error		P. Value *(Post hoc Bonferroni)*
SC1 vs SC2	-.7500*	0.2318		*0.011*
SC1 vs LC1	-.1000	0.2318		0.597
SC1 vs LC2	-.3000	0.2318		*0.002*
SC2 vs LC1	.6500*	0.2318		*.038*
SC2 vs LC2	.5500*	.2318		0.754
LC1 vs LC2	.0000	.2318		1.000

Bio root RCS with Single cone = SC 1; MTA Fill apex sealer with Single cone= SC2 Bio root RCS with Lateral condensation =LC1, MTA Fill apex sealer with Lateral condensation=LC2

Table 4: Sealer Distribution between the Groups in Coronal Third

Coronal Third	Mean	Std. Deviation	Std. Error	P value (ANOVA)
SC1	.800	.4104	.0918	*0.002*
SC2	1.600	.7539	.1686	
LC1	1.050	.6048	.1602	
LC2	1.250	.7164	.1352	
Groups	Mean Difference	Std. Error		P Value (*Post hoc Bonferroni)*
SC1 vs SC2	-.8000*	.2010		*.001*
SC1 vs LC1	-.4500	.2010		*<0.001*
SC1 vs LC2	-.2500	.2010		*0.003*
SC2 vs LC1	.3500	.2010		.514
SC2 vs LC2	.5500*	.2010		*.046*
LC1 vs LC2	.2000	.2010		1.000

Bio root RCS with Single cone = SC 1; MTA Fill apex sealer with Single cone= SC2 Bio root RCS with Lateral condensation =LC1, MTA Fill apex sealer with Lateral condensation=LC2

Discussion

Root canal sealers based on mineral trioxide aggregate are an outgrowth of the popular mineral trioxide aggregate materials, which are based on tricalcium silicates, used for various surgical and vital pulp treatment. This type of root canal sealer is attractive because of its hydrophilicity and bioactivity that has been reported for mineral trioxide aggregate-type materials. Calcium silicate-based sealers include some of the same compounds found in Portland cement, primarily tri-calcium silicate and di-calcium silicate particles, silicon dioxide, and bismuth oxide. It has suitable flow, good sealing, and low solubility and is indicated in cold and warm obturation techniques [9-14].

BioRoot RCS is a powder/liquid hydraulic tricalcium silicate-based cement and recommended for single- cone technique or cold lateral condensation root filling. The powder contains tricalcium silicate, povidone, and zirconium oxide; the liquid is an aqueous solution of calcium chloride and polycarboxylate [15] MTA Fillapex has two pastes with a base paste containing salicylate resins, natural resin, calcium tungstate, nanoparticulate silica, pigments and a catalyst paste consisting of diluting resin, mineral trioxide aggregate, nanoparticulate silica, and pigments. It has suitable flow, good sealing, and low solubility and is indicated for use in cold and warm root filling techniques [9, 15, 16].

The quality of the apical seal obtained by root canal obturation has been assessed by various methods like dye penetration, radio-isotope penetration, bacterial leakage study, electrochemical means, and fluid filtration technique. The dye penetration method used for measuring the apical microleakage is the most popular and easily performed [10]. Various dyes used are India ink, basic fuchsin, silver nitrate with a developer, and Methylene blue. Methylene blue has been used to compare microleakage in the present study. The sealability of a sealer should be as per the concept of the monoblock. Ideally, the root canal should be completely covered by sealer after obturation [15].

The final step of the root canal treatment is proper sealing of the apical foramen and all portals of entry to the periapical tissue with an inert material. Due to the complex patterns of root canal systems, numerous obturation techniques like cold lateral condensation, vertical condensation, single cone, and the latest heat delivery gutta-percha system have been innovated to ensure a better seal.[13] When the root canal is enlarged with rotary instruments, the use of either accessory points or the lateral condensation is not necessary, only the single-cone obturation technique can be used [13]. This technique of biomechanical preparation using the rotary files and thermoplastic obturation speeds the root canal filling while minimizes the pressure applied to the root canal walls [4, 10, 14]. However, lateral compaction of cold gutta-percha with a sealer has been the gold standard against which the other methods of canal obturation have been judged [10, 16].

The present study was done using two bioceramic sealers – BioRoot RCS and MTA Fillapex sealers and two obturation technique single cone and cold lateral condensation to compare the microleakage at the apical third using dye penetration and the sealer distribution along the root canal walls.

The stereomicroscopic examination showed that both the sealers and both the obturation techniques showed apical microleakage. There was no statistically significant difference between the groups. According to some studies, BioRoot RCS showed less microleakage when compared to MTA Fillapex [15, 16, 17, 19, 20]. Both the bioceramic sealers have good sealing properties,are biocompatible, and have calcium releasing ability [14]. There was a slight difference in the setting times of these two sealers which were <240 minutes for BioRoot RCS and 270minutes for MTA Fillapex. BioRoot RCS and MTA Fillapex had high solubility (>3%); these materials were more hydrophilic. They undergo hydration processes that continue after the final setting time and permit the ion release and calcium phosphate nucleation for 28 days [15, 16]. The high values of solubility in distilled water of the early set BioRoot RCS are correlated with high Ca^{2+} and OH^- release, which dissolve leaving voids. When immersed in a simulated body fluid, the calcium ions combined with phosphate promoting the formation of a superficial layer of Calcium phosphate able to fill the open voids. Clinically, this apatite forming ability with gutta-percha may improve sealing ability by the deposition of calcium phosphates at the interface [15-19].

The sealing ability of the BioRoot RCS sealer was found to be better than MTA Fillapex when examined under the stereomicroscope at three levels along the root length. The variation in the results could be due to the shape of the canal of the single-rooted premolars which showed less tapering at the apical third and flare at the middle third and coronal third [19].

Concerning sealer distribution examination, the samples were cross-sectioned at a distance of 3, 6 and 9 mm from the apex and examined under a stereomicroscope at 30x magnification

In the SC group, a GP cone lightly coated with sealer was gently seated to the working length On obturating with single cone there was more sealer along the root canal walls than with lateral condensation at 6mm and 9mm sections of the samples. LC was achieved in each canal by using eight to 10 additional GP cones (size 25) and an endodontic finger spreader that initially reached to within 2 mm of the full working length. The tip of each additional GP cone was lightly coated with sealer. Lateral condensation techniques showed more cones and less sealer at 6mm and 9mm sections due to dispersion of sealers due to the condensation force [17, 21, 24].

It was found that the sealer distribution of BioRoot RCS sealer with single cone obturation was better when compared to the cold lateral condensation using the same sealer. On comparing the sealer distribution at 3mm, 6mm, and 9mm margins there was no statistical difference in the amount sealer distribution at 3mm margin, both the sealers showed sealer loss with the cold lateral condensation obturation techniques [20-23]. This result was following the concept that obturating the root canal space with a combination of a single cone with bioceramic sealer has better sealing ability compared to lateral condensation technique [15, 20, 24-26].

The total amount of sealer brought into canals by the GP points was larger in the LC group than in the SC group. However, the canal wall was better covered in the SC group, indicating that more sealer does not always result in a better sealer coverage. There was no statistically significant difference between the other groups -BioRoot RCS with lateral condensation, MTA Fillapex with single cone and lateral condensation [24-27].

Conclusion

Within the limitations of this study, the results showed that the comparisons between the two bioceramic sealers and the two obturation techniques showed almost similar results on examining under a stereo microscope for apical microleakage. The findings were statistically insignificant between the two Bioceramic sealers. However Single cone obturation with Bio root RCS showed less apical microleakage than the other groups. On examining the sealer distribution along the root canal length, it was found that Single cone obturation with both the sealers showed better distribution than the rest of the groups. There was a statistically significant difference between all the groups, it was very minimal. Therefore, it can be concluded that all these sealers and techniques were statistically similar and can be clinically used according to the judgment of the clinician. In other words, the selection of these materials does play a major role in decreasing the microleakage, and other factors can be used to determine the material of choice for any particular clinical situation.

Acknowledgments

Conflicts of Interest

Nil

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