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Comparative Evaluation of Marginal Adaptation of Bioceramic and Resin Sealers With Different Obturation Techniques (AN IN-VITRO STUDY)

Abstract

Objective To evaluate and compare the marginal adaptation of epoxy resin-based sealer (AH Plus) versus Bioceramic-based sealer (Total fill BC Sealer) to root canals that were filled by single cone technique & Cold Lateral compaction technique and utilizing scanning electron microscope (SEM).

Methods

Sixty recently extracted single-rooted mandibular premolars were disinfected. Access cavity preparation was performed followed by cleaning and shaping, using 2.6% NaOCl as final irrigation protocol. Samples were then equally divided into 4

different groups as follows; Group A: AH Plus with CLC technique, Group B: AH Plus with SC technique, Group C: Totalfill BC with CLC technique, and Group D**:** Total fill Bioceramic sealer with single cone technique. After cleaning and shaping, each sample was obturated with Gutta percha and the sealer according to group of allocation. Afterwards, Transverse sectioning of each root was done at three, six, nine millimeters from the root apex corresponding to the three thirds of the root (apical, middle and coronal thirds). The specimens have been examined under scanning electron microscope (SEM). A commercially accessible software programme (SPSS Chicago, IL, USA) was used for the statistical analysis. The mean and standard deviation were used to describe numerical data. According to data normality, the Kruskall Wallis or ANOVA test was used to compare the data. A P 0.05 significance threshold was used. Every test had two tails.

Results

BC sealer presented better marginal adaptation than AH Plus sealer. However, On marginal adaption, there was no discernible difference between the two examined obturation techniques.

Conclusion

BC sealer is a reliable and promising material that improves marginal adaptation.

Keywords: AH Plus sealer, BC sealer, Cold lateral condensation, Marginal adaptation, Single cone obturation.

Introduction

By creating an appropriate seal against bacterial infiltration and associated toxins, root canal filling serves to avoid canal reinfection. To accomplish this goal, root sealers and gutta-percha (GP) are combined. Sealers establish a bond between Gutta percha and the dentin of root canal, obliterate any remaining germs, patent

auxiliary canals, and patent several foramina. Sealers are therefore crucial to the effectiveness of root canal treatments. Reducing the sealer amount applied and maintaining good adaption and penetration of the sealer into root dentin can increase the effectiveness of root sealers. greater dentin-sealer contact surface area leads to greater antibacterial action at the sealer-dentin interface, which increases root sealer effectiveness. However, the physical and chemical characteristics of the sealer play a significant role in its thickness and adaptability to root dentin. (1)

Due to its flow, dimensional stability, low solubility, low concentration, and appropriate radiopacity, AH Plus is an epoxy-based sealer that has been used extensively for many years. Resistance. Compared to glass ionomer sealers, zinc oxide, calcium hydroxide, and calcium oxide, it has demonstrated a stronger bond to dentin. (2)

Endodontic sealers of a new generation, including EndosealMTA, MTA Fillapex, Total Fill BC, SealeriRoot SP, EndoSequence BC Sealer, and ProRoot Endo Sealer, have been developed based on calcium silicate. When a bioceramic sealer is setting, hydroxy apatite is formed, which eventually forms a chemical bond between the sealer and the dentinal wall.(3)

Due to its simplicity and suitability for the majority of instances, lateral compaction of cold gutta percha is a common method used by practitioners around the world to fill root canals. Lateral compaction is the standared method for assessing alternative obturation techniques .(4)

Considering how well the single cone approach adapts to the canal wall, it is commonly used. The advantage of this method is that it requires less treatment time than lateral compaction. (5)

Materials and methods

Sample size:

Teeth were collected from patients following ethical approval, regulations, and guidelines of the Research Ethics Committee (REC) of Faculty of oral and dental medicine Future University (Approval No. or REC code (12)/5- 2020. In light of earlier research by Eltair el al (2017) [6], There were 4 subgroups created from the sample size. In order to determine an effect size of 0.45, a power of 80%, and a significance level of 5%, a total sample size of 48 (12 each group) was needed. To accommodate the result variable's non-parametric distribution, the number was raised to a sample size of 52. To account for anticipated preparation-related losses, an additional 20% increase was required, bringing the total to 60 (15 per group). Using the G power programme, sample size was estimated. [7]

Teeth selection:

Sixty recently extracted single rooted mandibular premolars teeth for either periodontal or orthodontic reasons were collected from the outpatient clinic of oral surgery department, Faculty of Oral and Dental Medicine, Future University in Egypt. The selected teeth were examined radiographically to ensure the inclusion standards including intact roots, mature apices, and straight single root canals. Exclusion criteria include signs of cracks, fracture, caries, external resorption, calcification, or internal resorption, and teeth with previous root canal treatment, severe apical curvatures, or more than 1 root.

Preparation of teeth:

The collected teeth were soaked in 5.25% sodium hypochlorite solution (NaOCl) for 30 minutes to remove tissue debris adhering to root surface. Any

remaining soft tissues or calculus were eliminated using an ultrasonic scaler, then the teeth were rinsed in tap water and keeped in clean glass bottles that contained normal saline solution (0.9%NaCl) until time of use**.** Before canal instrumentation, samples were de-coronated at cementoenamel junction and standardization of root lengths were set at 17 mm (figure 1).

Figure (1): A photograph showing root with standard length of 17 mm

Mechanical preparation:

Patent canals were ensured through manual K-file size #10. The file should passively fit until the apical foramen can barely see its tip. Subtracting 1mm from this length yielded the working length. ProTaper Next nickel-titanium rotary devices were utilised in accordance with the manufacturer's instructions to mechanically prepare the root canals using the crown down technique.

Using a gentle in and out brushing action, On an Electric motor-driven ProTaper Next rotary files were set to rotate at 300 rpm and 2 N cm of torque until the working length was passively attained. One or more passes utilised the X1 (17/04) file in the presence of NaOCl solution, alternating if necessary with small-sized hand files, until the working length was attained. The X2 (25/06) file was utilised

in the same manner as the X1 file up until the working length was passively achieved. If the size 25 K-file was loose at the length after measuring the canal, the canal was further shaped with an X3 (30/07) master apical file.

All canals have been properly prepared When a hand K-file with an ISO size matching the tip size of the employed ProTaper next file fits the apical third of the canal at the working length. Using a plastic disposable syringe with a side-vented needle gauge #30, the canals were completely irrigated with 2ml of newly made 2.6% sodium hypochlorite (NaOCl) solution between each consecutive instrument. Rubber stoppers confirmed that it was passively introduced into the canal 2 mm short of the working length without any forceful irrigant dispensing.

The amount of irrigation solution was steady (2 ml) after each file to achieve uniformity. A 17% ethylenediaminetetraacetic acid (EDTA) lubricant was used with each file. After completion of instrumentation, irrigation of canals were performed with Sodium hypochlorite 2.5% then EDTA (17%).

Alignment of samples:

The Sixty samples have been splitted to 4 equal divisions (n=15) in accordance with the sealer and root canal obturation technique category used.

Root canal obturation:

After the biomechanical instrumentation of the root canals was finished. ProTaper Next absorbent paper points that were the same size as the master file (X3) were used to completely dry each root canal.

Group A: AH plus sealer with Cold lateral compaction technique:

The root canals were then obturated using #35/2% GP cones & AH+ with lateral compaction technique. The master GP cone was precisely checked

visually & radiographically to fit within 0.5 mm of the working length.

Group B: AH plus sealer with single cone technique:

The samples have been obturated with the single-cone method through appropriate selecting of the GP point (PTN-GP) that corresponds to the size and taper of the MAF and snugly fits within 0.5 mm of the working length. And the AH+ was used.

Group C: Total fill Bioceramic sealer with Cold lateral compaction technique:

The root canals were obturated using size #35/2% GP cones & Totalfill BC root canal sealer using lateral compaction technique.

Group D: Total fill Bioceramic sealer with single cone technique:

The samples have been obturated with the single-cone method utilizing the PTN gutta percha and Totalfill Bioceramic RC sealer.

SEM assessment:

Specimen preparation

Seven days following the obturation, each root has been cut perpendicularly to its long axis at three, six, nine millimeters from the apices (figure 2) by means of double coated diamond end cutting disc installed on a straight hand piece under constant water cooling. The disc was used to cut a deep groove into the outer side of the root without reaching the internal portion of the canal; this was followed by splitting each section by sharp chisel and mallet to obtain disk-shaped sections (n = 180).

Then cleaning of the samples in an ultrasound bath for 2 min to remove damages or deformed surface material, every section has been properly dried & tested via a light microscopy which was equipped with a digital camera for confirmation that both the root canal sealer and the GP cones were not detached.

Figu *oning of th*

SEM imaging

Dehydration of the samples was performed through raising the percentage of paraethylene alcoholic acid. Afterwards, the samples had been placed in AL framing then tested via scanning electron microscopy.

Micro-photographs had been captured with magnification 3K, afterwards the width or the inner voids in-between root canal dentine & obturating materials(sealer) at 3 random spots within the 3 root canal thirds had been calculated in microns/mms utilizing a specified photo device to evaluate the marginal adaptation of the root canal sealers under testing.

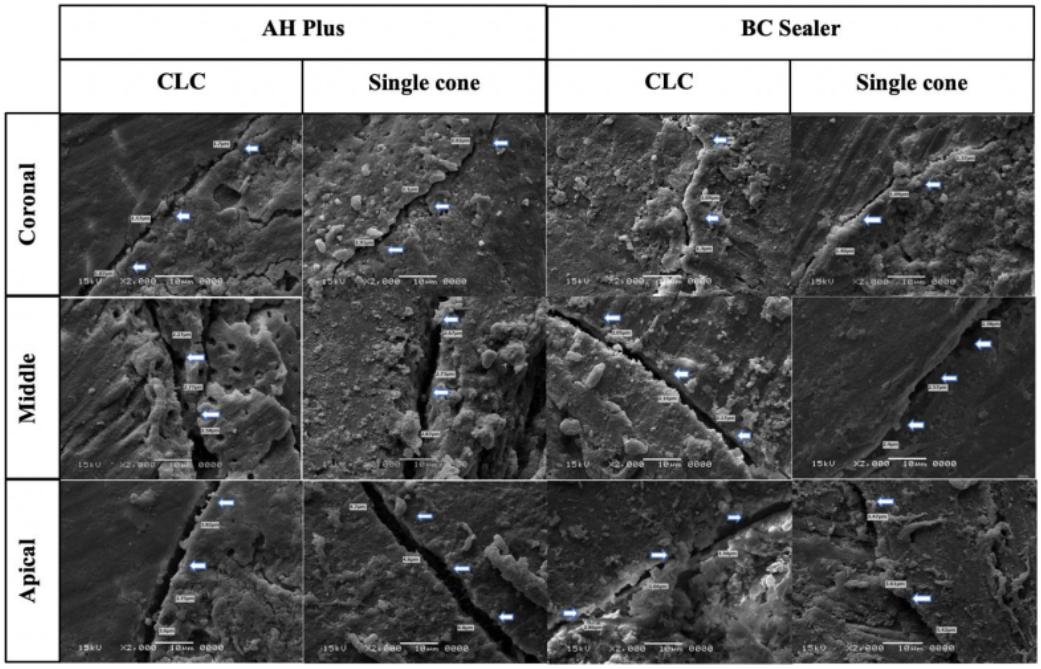

Figure (3): Images of scanning electron microscope of the coronal, middle, and apical level of the root obturated with either AH Plus or BC sealer and Protaper Next GP by either CLC or single cone technique (X 2000) showing adaptation of obturation to the margin

Statistical analysis:

A commercially accessible software programme (SPSS Chicago, IL, USA) was utilized for the statistical analysis. The mean and standard deviation were utilized to describe numerical data. According to data normality, the Kruskall Wallis or ANOVA test was used to contrast the data.The level of significance will be set at P ≤0.05. All tests will be two tailed.

Results

There was a statistically significant difference between Coronal and the other 2 groups (Middle and Apical). No statistically significant difference was found between Middle and Apical groups. The highest mean value was found in Apical followed by Middle group, while the least mean value was found in Coronal group.

As regard obturation technique there was no statistically significant difference in-between single cone technique and the Cold lateral condensation technique. The lowest values were found in the Cold lateral condensation group, however the maximal values were found in the Single cone group.

As regard sealer used, there was statistic significance differences between AH+ epoxy-resin root canal sealer group and the Total fill bioceramic root canal sealer group. The lowest values were found in AH+ epoxy-resin root canal sealer group plus , however the maximal values were found in the Total fill bioceramic root canal sealer group.

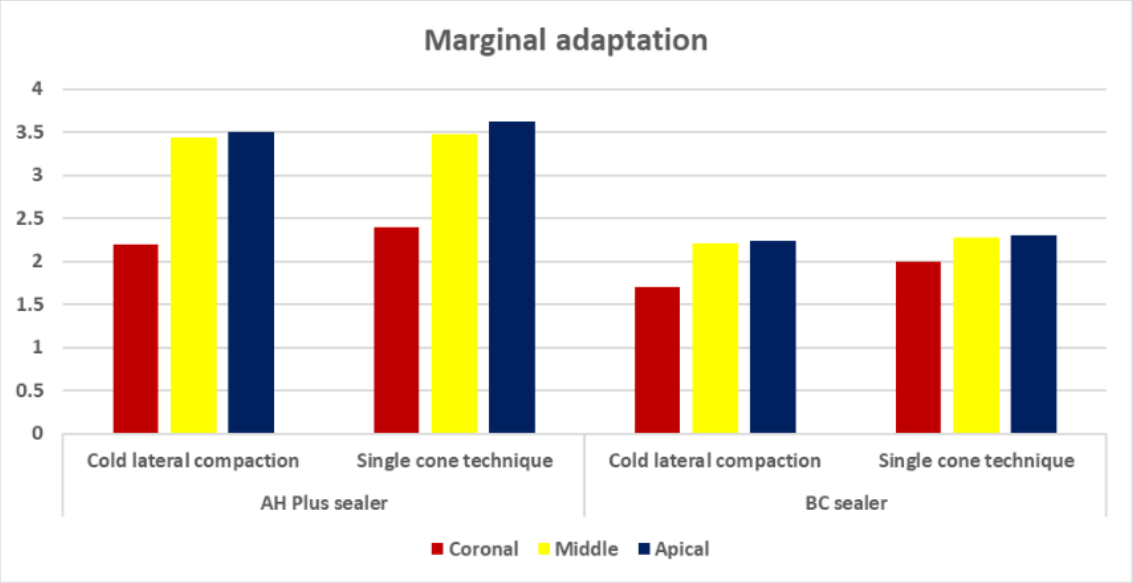

Figure (9): Bar chart showing the effect of thirds on the margin adaptability

Discussion

The primary objective of endodontic treatment is the capability to irradicate irritants, to clean, shape and fill the root canal three-dimensionally and prevent recontamination from bacterial byproducts and toxins, moreover, the long term success in root canal treatment is due to the three-dimensional obturation of the root canals in order to prevent the ingress of bacteria and their toxins into the periapical tissues.[8] Root canal filling with no voids and to the proper working length are important factors affecting the efficiency of the successful endodontic treatment.[9] Appropriate physical properties of the filling material (gutta percha) make it possible to be applied in several techniques and modalities. [10] Obturation of root canals with gutta-percha and root canal sealants is the gold standard in RCTs. Root canal sealants have certain drawbacks despite their many advantages, such as their inability to entirely bond with the dentin that lines the root canals. Due to the hydrophobic nature of gutta-percha, the sealer may potentially pull

away from the gutta percha while setting.[11] As little as 1% shrinkage of root canal sealers can produce flaws large enough for the entrance of bacteria or their byproducts, minimising the gaps between the sealer and gutta-percha and/or dentin surfaces is clinically relevant.inimizing the gaps between the sealer and gutta-percha and/or dentin interfaces is clinically relevant as little as 1% shrinkage of root canal sealers can result in imperfections that are large enough for the penetration of bacteria or their by-products.[12]

Single rooted mandibular premolars were used in this study for its greater predictability of the cleaning and shaping procedure.[13] Teeth were collected and then disinfected by 5.25% NaOCl solution for 30 min to remove tissue debris adhere to root surface and reduce bacterial accumulation and to minimize the risk of blood borne pathogen.[14][15] The teeth were scaled by ultrasonic scaler to remove hard tissue, gross debris and calculus, and were then stored in clean glass bottles containing normal saline solution (0.9% NaCl).[16] Radiographs were taken buccolingually and mesiodistally to make sure that all the teeth were with type I canals system according to Vertucci FJ classification, caries free with completely formed apex with patent foramina , with no obstruction within canal system , no crack formation or internal or external root resorption, without any anatomic abnormalities, and without previous endodontical treatment.

To standardise samples and eliminate human variability that might be related to the preparation of the coronal access cavity, the crowns were decapitated at the cemento-enamel junction. which could affect the proposed root canal preparation and obturation techniques.[17] Using the ProTaper next rotary system to X3 (30/07), all root canals were mechanically prepped in accordance with manufacturer instructions using a crown-down technique. The coronal enlargement provided by the crown-down approach serves as a reservoir for the irrigating solution enabling improved irrigant penetration in the apical third while also improving root canal

debridement and reducing strains during instrumentation.[18] Protaper Next is a rotary system that has been popular for preparing root canals, and some studies suggested that this system result in preparing a canal that is more uniform, better centered, and rounder. It also provides a unique geometries, flexibility, efficiency, safety, and simplicity.[19]

NaOCl irrigant at 2.6% in 30-gauge side-vent Navi Tip irrigating needle has been used in this study for its pulp solvent activity and antimicrobial properties.[20] At the end of instrumentation of the root canals, the smear layer was removed by rinsing with 2 ml of 2.6% NaOCl for 1 minute to remove the organic components of the smear layer followed by 2 ml of 17% EDTA for 1 minute to remove the inorganic components.[21] EDTA can easily penetrate the dentine tubules due to its low surface tension and eliminates the inorganic part of smear layer to a depth up to 2.5-4 µm.[22] Thus bonding and adaptation of sealer to root walls is increased.[23] Studies found that the presence of smear layer may impede the penetration of sealers into the dentinal tubules of root canals and also interfere with the adhesion of gutta-percha.[24][25] Finally, distilled water was applied to offset the lasting impact of the irrigations, and the canal was dried to remove moisture.

Because a sealing substance is required to attach the gutta-percha to the root canal walls and to cover lateral canals, auxiliary canals, voids, and irregularities, root canal sealer is very important. Thus, enhancing the root filling's adaptability at the dentin/material interface.[26] [27]

Ideally, root canal sealers must be biocompatible, have low surface tension and have better wettability to provide fluid-tight seal.[28] Epoxy resin-based root canal sealers (AH plus) has been successfully used for many years and because its advantages in relation to good adaptation and bond strength in comparison with

other materials.[29] AH Plus is an epoxy resin based sealer, consists of paste-paste system and delivered in two tubes. AH Plus has a film thickness of 26 mm, which is clearly below the value of less than 50mm required by the ISO standard for root canal sealing materials.[30] Epoxy resin-based sealers offer noticeable physical features and excellent apical sealing, ensuring acceptable biological performance. However, it has a number of drawbacks with regard to clinical use, radiopacity, and retreatability.[31]

The BC sealer as described by the manufacturer is a slow-setting injectable, pre-mixed, hydrophilic material, based on a calcium silicate composition. It is a water-based sealer. BC was used for this study since it has been the most commonly used. Its high antibacterial activity, outstanding sealing ability, excellent bond strength, good flowability, low shrinkage, and insoluble properties have all been demonstrated in several in vitro studies. Its chemical composition much stronger, which helps it penetrate deeper into the surface micro-irregularities, as well as within the lateral root canals. [32], [33]

These sealers release calcium and create an interfacial calcium phosphate (apatite) layer when they come into contact with the physiologic solution, forming a chemical interaction with the dentinal walls. [34],[35]

Various obturation techniques have been used in endodontics aiming to achieve marginal adaptation and to minimize the film thickness of the cement to a minimum.[36] Cold lateral compaction (CLC) is a the most common method among practitioners , however the main drawback of this technique is that it provides least condensation of gutta-percha cones against each others and against the dentinal canal walls, non-homogenous, and in between the cones has gaps.[37]Nevertheless, this technique rely on the use of the single bigger gutta percha cone that matches the size and taper of the last rotary instrument taken to the full working length of

the root canal after the canal had been properly shaped, disinfected and dried with sterile paper points. [38] The use of those gutta percha cones does not indicate the use of any auxiliary cones or compaction laterally or even warm compaction vertically when the root canal is already enlarged with the rotary instruments. [39]. The single gutta percha cone is coated with the root canal sealer and inserted passively to the full working length resulting in a properly uniform homogenous mass that eliminates the type of failure that might be accompanied with the use of multiple gutta percha points. [40] This simplified method is very efficient and less time consuming than any of the traditional methods of compacting gutta percha. [41] From the clinical point of view, the patient and operator fatigue were reduced, cervical/coronal dentin is more preserved, and the lateral pressure that may lead to cracks or fractures due to the use of spreaders or pluggers is almost eliminated resulting in more durable and successful root canal treatment. [42]

In order to assure complete setting of the sealers and reduce the final setting time, the respective sealer samples were obturated and then stored in a humidor for a week. [43] To allow the sealers to set, Patri et al. [44] put the samples in a humidor for 7 days.Loushine et al. [45] and Jafri et al. [46] showed EndoSequence BC forming a more permeable matrix and have increased initial setting time (7 days) and reduced micro-hardness of the set cement with the increase in quantity of water in the course of the setting of sealer. There are several methods to evaluate marginal adaptation and sealing ability such as dye penetration method, electrochemical methods, fluid filtration technique, radioisotope tracing, stereomicroscopy, microcomputed tomography, confocal laser microscopy, digital imaging, leakage test, and scan electron microscope[34]. In this study, scanning electron microscope was used for assessment of adaptation of sealers to canal walls and marginal gaps. The benefit of employing SEM over other techniques is that it allows for the observation of defects at the submicron level at a required magnification and

allows for the preservation of microphotographs for final evaluation.[47] It enable investigation of the root canal sealer penetration into the dentinal tubules, examination of ultrastructure morphology, and evaluation of the sealer adaptation to the radicular dentinal walls on the different levels of sectioning because it has high depth of field, excellent magnification at the interface, and higher resolution.[6] This has also been stated by ElAsfouri And Saba.[35]

The roots from each group were cut transversely at three different levels (Coronal, Middle and Apical) for examination under scanning electron microscope to evaluate the adaptation of the tested sealers under each preparatory condition. In some studies, longitudinal sections are made, especially when the coronal or middle part of the root canal is evaluated or when the location of the evaluation is not mentioned[48]. Adaptation of gutta-percha in the two techniques were measured in cross sections of the root at 3, 6, 9 mm from the apex which represent apical, middle, coronal sections respectively. This is controversial to a study done by Jarrett et al. [49] who sectioned the specimens at only 2,4 mm and stated that this research had several limitations where only two areas of the canal were evaluated and that different findings might have been present at other levels. Sectioning was done under copious water irrigation which was important to reduce frictional heat with gutta-percha.[50]

In our study, the highest margin adaptability values were displayed in TotalFill bio-ceramic root canal sealer then the AH+ epoxy resin sealer. This is explained by the caustic and alkaline impact of calcium silicate sealant moisturising products, which have been shown to degrade the collagenous component of the intermediate dentin. This may therefore make it easier for the plugs to penetrate the dentinal tubules. [51] In addition, the bioceramic sealer has a low contact angle, is hydrophilic, and may spread readily across the canal wall to provide adaptability. [52] Additionally, the primer capillary tip system may have

improved its penetration to the entire length of the canal due to the extremely tiny particle size and ideal pre-mixed consistency given by the system.[53] This was in agreement with the research by Patri et al.[44], which showed that EndoSequence BC sealers increased flow and reduced film thickness. In addition, Polineni et al.[54] noted that the alkaline nature of the bioceramic byproducts, which denatures the collagen fibres of dentin, may allow the sealers to penetrate the dentinal tubules. The hydrophilic sealers show greater marginal adaption and lower apical microleakage values, according to Hegde and Arora[55] .This finding contradicts with the results obtained by Polineni et al.[54] who observed a low marginal gap in epoxy resin based sealer MM Seal, and attributed the superior adaptation of MM Seal to its ability to bond to root dentin chemically by reacting with exposed amino groups in collagen to form covalent bonds between the collagen and resin upon opening of epoxide ring.[56]. AH Plus is somewhat acidic compared to alkaline bioceramic-based sealers and may cause self-etching when in contact with dentin, improving interfacial bonding and adaption. [57]

Alhadad et al.[57] found that the better marginal adaptation of AH Plus may be related to the EDTA used as the irrigant between instrumentation for more than 1 minute. The wetting ability of dentinal walls has been shown to be decreased by EDTA. [58], which creates a condition that is conducive to the adherence of hydrophobic materials like AH Plus and effective micro-retention. However, the dentin surface's diminished wetting capacity prevented the attachment of any hydrophilic elements. [59] like Totalfill bioceramic sealer. A similar SEM examination and founding was performed by Arikatla et al. [34] who attributed the inferior adaptation of BC sealer could be due to poor microtags formed on setting.

Disregarding the type of root canal sealer in this study, the superior margin adaptability values were displayed in the Cold lateral compaction method then the Single Cone obturation technique. This could be attributed by the spreader

compacting the gutta percha cones by applying pressure over the master and accessory cones, which may provide force in both the lateral and apical directions that enhance adaptation to the canal imperfections.[60] the Single cone obturation technique is often associated with a good outcome in the round, narrow and regular root canals. However, the outcome may not be that satisfactory in root canals with irregular shapes due to the larger amounts of sealer accumulating in those irregularities that may lead to appearance of internal voids due to the unavoidable contraction due to setting reaction and degree of dissolution that finally results in inferior outcome in terms of margin adaptability of sealers to the dentinal root canal walls. Al-Sabawi et al[42] who found the highest marginal adaptation of bioceramic sealer was in the root canals that were obturated with the CL techniques. Contrary to this finding, Inan et al.[61] and Ismail et al.[62] in their study reported less adaptation in samples obturated using lateral compaction technique compared to single cone obturation technique.

The creation of a non-homogenous mass of gutta percha that does not properly reproduce the prepared root canal space and does not adequately obturate simulated lateral canals may be the cause of the greater number of gaps in the samples obturated using the CLC technique. Some authors [63][64] reported similar adaptation with single cone and lateral compaction groups. According to them, in the case of CLC technique, the spreader penetration causes satisfactory marginal adaptation, and in the case of the SC technique, the cone having the same taper with the rotary nickle titanium instruments provide good marginal adaptation. The SC technique showed less marginal adaptation and larger mean of gaps especially at the apical section of the root. Additionally, Celikten et al. [52] discovered that voids existed for all root filling and obturation techniques. With the studied bioceramic sealer, void volumes were largest for the SC method and lowest for CLC at all levels..

In this study, the coronal section had significantly fewer gaps than the apical and middle sections. For all samples, there were more gaps at the apical level than at the coronal level. The reduced density and diameter of dentinal tubules found at the apical area can be used to explain this disparity.(65) Additionally, the intermolecular surface energy and cleanliness of the dentin as well as the surface tension and wetting ability of the sealant have a significant role in the degree of the sealer's adhesion to the dentin wall. Different surface energies and levels of cleanliness can be found in the coronal, intermediate, and apical regions of dentin. Since it can be challenging to remove the smear layer in the apical area, cleanliness is a crucial component for sealer adaptation. It was proposed that the disparities between the apical and coronal regions may be caused by the reduced density and diameter of dentin tubules in the apical regions. The smear layer frequently prevents sealer passage to the dentin tubules. (66) This result supports the explanation put forth by Arikatla et al. (34), who connected it to the reduced density and smaller diameter of dentinal tubules present in the apical area.

According to Polineni et al.'s (54) research, the apical third's difficult smear layer removal may serve as a physical barrier that prevents the sealer from adhering to the root canal dentin in addition to the low density and diameter of dentinal tubules there.

Conclusion

Within the limitation of this study, it could be concluded that bioceramic sealer is an appropriate, reliable and promising material that improves the marginal adaptation. Techniques of obturation had an effect on the marginal adaptation of the sealer to the root canal walls where (CLC) lateral condensation

method proved to be credible method enhancing the adaptability to the dentinal root canal walls.

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