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EVALUATION OF SEALING ABILITY AND PUSH-OUT BOND STRENGTH OF DIFFERENT SEALERS (AN IN VITRO STUDY)

***Ahmed Zaki Mamdouh Sallam, Prof. Dr. Ehab Elsayed Hassanien, Dr. Mohamed Mokhtar Nagi**

Department of Endodontics, Faculty of Dentistry, Ain Shams University.

***Corresponding Author: Ahmed Zaki Mamdouh Sallam**

Department of Endodontics, Faculty of Dentistry, Ain Shams University.

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ABSTRACT

Background: Choosing an endodontic sealer for clinical use is a decision that contributes to the long-term success of NSRCT. The long-term success of endodontic therapies relies on complete filling after root canal obturation. Microleakage is one of the significant causes for endodontic failure, which occurs due to poor contacts between the gutta-percha and the seal-er, the sealer and the dentin, or through voids within the sealer. **Aim of the Study:** This study evaluated the sealing ability and push out bond strength of root Epoxy resin-based sealer (ADseal), Two bioceramic based sealers (CeraSeal bioceramic sealer) (Ceramoseal bioceramic sealer) and zinc-oxide based sealer (Zical). **Materials and Methods:** This study established on 60 extracted sound human single rooted premolars teeth with straight roots and single root canal were collected from the outpatient clinic in Oral Surgery department at Faculty of Dentistry, Ain Shams University. By inspection under magnification, teeth with severe attrition, root caries, external root resorption or cracks were excluded. The samples were classified into four main groups according to the obturation sealer: group I (n=16): ADseal sealer, group II (n=16): CeraSeal sealer, group III (n=16): Ceramoseal sealer, group IV (n=16): Zinc-oxide sealer. Each group were subdivided into two subgroups with 8 samples in each subgroup according to the method of evaluation: subgroup A (n=8): Sealing ability, subgroup B (n=8): Push-out bond strength. **Results:** Regarding the sealing ability test, there was no significant difference among the different types of sealers at 1 day and at 1 week. Regarding intergroup comparison, there was no significant difference within the same group at 1 day and 1 week in ADSeal sealer group Ceraseal sealer group, Ceramoseal sealer Zical sealer group. Regarding Push out test, there was no significant difference at corneal section between ADSeal, Ceraseal, Ceramoseal, and Zical. There was no significant difference at middle section between ADSeal, Ceraseal, Ceramoseal, and Zical, and apical section between ADSeal, Ceraseal, Ceramoseal, and Zical group. There was no significant difference between corneal section, middle and apical section at ADSeal, Ceraseal, Ceramoseal, and Zical. **Conclusion:** From the findings of this in vitro study, the following conclusions can be drawn under the sealing ability was comparable between ADSeal, Ceraseal, Ceramoseal and Zical sealer in 1day and 1 week, the push out technique was comparable between ADSeal, Ceraseal, Ceramoseal and Zical sealer in 1day and 1 week, sealing ability and push out bond strength are strongly correlated with each other.

KEYWORDS: Sealing Ability, Push-out Bond Strength, Sealers.

INTRODUCTION

The success of the endodontic obturation depends not only on an effective mechanical debridement of the root canal, but also on the level and quality of the obturation, which can be influenced by the type of material used, the technique applied, and by factors inherent to the preparation of the canal, such as the correct determination of the working length.[1]

Endodontic treatment aims to eliminate infection of the root canal and to completely fill the root canal space in three-dimension, in order to prevent apical and coronal penetration of liquids and microorganisms.[2]

Most root canals are filled with gutta-percha points in combination with an endodontic sealer which are essential components of root canal obturation to establish a fluid-tight seal. The main function of a sealer is to fill the spaces between the core material and the walls of root canal and between the gutta-percha cones, to form a coherent mass of obturating material without voids. The sealer is expected to fill irregularities and minor discrepancies between the filling and canal walls, accessory canals, and multiple foramina. By its germicidal action, it is also expected to destroy the remaining bacteria left after cleaning and shaping of the root canal.[3]

Choosing an endodontic sealer for clinical use is a decision that contributes to the long-term success of non-surgical root canal treatment (NSRCT).[4]

The long-term success of endodontic therapies relies on complete filling after root canal obturation. Microleakage is one of the significant causes for endodontic failure, which occurs due to poor contacts between the gutta-percha and the seal-er, the sealer and the dentin, or through voids within the sealer.[5]

It is not easy to achieve a complete filling with the current root-filling materials used in the clinic, due to the dimensional changes and lack of adhesion from gut-ta-percha, which is also the reason to use endodontic sealers in combination of gutta-percha. Thus, the adaptability of a sealer to the dentin is the primary factor influencing microleakage and reinfection of the root canal.[6] On the other hand, Push-out bond strength testing has become a common method for determining the effectiveness of adhesion between endodontic materials and intraradicular dentin.[7]

Many sealer have been introduced like Epoxy resin-based sealer (ADseal), Two bioceramic based sealers (CeraSeal bioceramic sealer) (Ceramoseal bioceramic sealer) and zinc-oxide based sealer (Zical). One of the recent epoxy resin-based sealer is ADseal, with excellent chemical, physical properties and sealing ability. These characteristics are responsible for the superiority of this sealer over the other epoxy resin-based sealers.[8]

Bioceramic based endodontic sealers have been introduced recently in clinical dental practice, containing zirconiaoxid, calcium silicate, calcium monobasic phosphate, calcium hydroxide and various filling and thickening agents. These materials are usually available in calibrated syringe with mixing tips. They pre-sent hydrophilic properties, using intra-canalar moisture to complete the setting reaction and are setting contraction free.[9]

Ceraseal (Meta Biomed Co., Cheongju, Korea) is a newly launched premixed endodontic sealer containing calcium silicates, zirconium oxide, and thickening agent. CeraSeal Calcium Silicate-based Bioceramic Root Canal Sealer Calcium silicate-based CeraSeal provides optimal biocompatible environment to tissues in the root canal. It is obviously the next generation bioceramic-sealer which has excellent sealing ability and biocompatibility. Unlike conventional base/catalyst sealers, Ceramoseal BC Sealer utilizes the moisture naturally present in the dentinal tubules to initiate its setting reaction. This highly radiopaque and hydrophilic sealer from hydroxyapatite upon setting and chemically bonds dentine and gutta percha points. Ceramoseal BC is biocompatible, highly radiopaque, with ideal working time and setting time, highly alkaline pH and unlike traditional sealers, it exhibits absolutely zero shrinkage.[10]

Epoxy resin-based sealers have excellent physical properties such as longer setting time, low solubility, high flow rate, low volumetric polymerization shrinkage, and interfacial adaptation and also are related to covalent bonds between epoxide rings and the exposed amino groups in the collagen network.[11]

The most commonly used sealers in root canal treatment are ZOE-based sealers, which have been modified for endodontic purposes. The powder of these sealers contains zinc oxide (ZnO), which combines with a liquid, generally eugenol. The valuable component of these sealers is ZnO, an II-VI semiconductor compound which is stably crystallized in a hexagonal wurtzite structure.[12]

To the best of our knowledge,there is lack of studies that compared sealing ability and bond strength of these sealers.

Null hypothesis: There is no difference between sealers regarding to sealing ability and push out bond strength.

AIM OF THE STUDY

The aim of the study was to assess the push-out bond strength & sealing ability of different types of sealers: ceraSeal Bioceramic sealer, ceramoseal Bioceramic premixed with MTA, epoxy resin-based sealer, zinc-Oxide based sealer.

MATERIALS AND METHODS

Materials

1. ADseal sealer
2. CeraSeal bioceraic sealer Ceramoseal bioceramic sealer
3. Ceramoseal bioceramic sealer
4. Zinc-Oxide Sealer

Methods

Sample size calculation

Microleakage

A statistical sample size calculation was performed using the G-power program with 32 total sample size. An alpha-type error of 0.05, a beta power of 0.95 and an effect of size of 0.8484668, while the mean and standard deviation were obtained from a previous study.

Push out

A statistical sample size calculation was performed using the G-power program with 32 total sample size. An alpha-type error of 0.05, a beta power of 0.95 and an effect of size of 0.8339604, while the mean and standard deviation were obtained from a previous study. Sample size calculation revealed that sixty-four extracted sound human single rooted premolars teeth with straight roots and single root canal were collected from the outpatient clinic in Oral Surgery department at Faculty of Dentistry, Ain Shams University. By inspection under magnification, teeth with severe attrition, root caries, external root resorption or cracks were excluded.

Sample preparation

A total of 64 teeth were washed in running tap water, cleaned of any attached tissue, autoclaved, and stored in saline solution until use. Radiographic evaluation was done to check the number of the canals. The teeth were decoronated using low speed diamond disc with water coolant, and the length was standardized at 15 mm for all samples. Root canals were prepared using K-files and Mpro files with 2.5% sodium hypochlorite irrigation solution. All teeth were prepared up to 35 6% and manual k-file size 50 as a master apical file followed by final irrigation with 15mL of 2.5% sodium hypochlorite and saline in between and 15 mL of 17% EDTA. All canals were dried using paper points. All samples were randomly divided into four main groups (I, II, III, IV) with 16 samples in each group.

Samples classification

The samples were classified into four main groups according to the obturation sealer (Figure 1-5): group I (n=16): ADseal sealer, group II (n=16): CeraSeal sealer, group III (n=16): Ceramoseal sealer, group IV (n=16): Zinc-oxide sealer.

Each group were subdivided into two subgroups with 8 samples in each subgroup according to the method of evaluation: **subgroup A (n=8):** Sealing ability, **subgroup B (n=8):** Push-out bond strength.

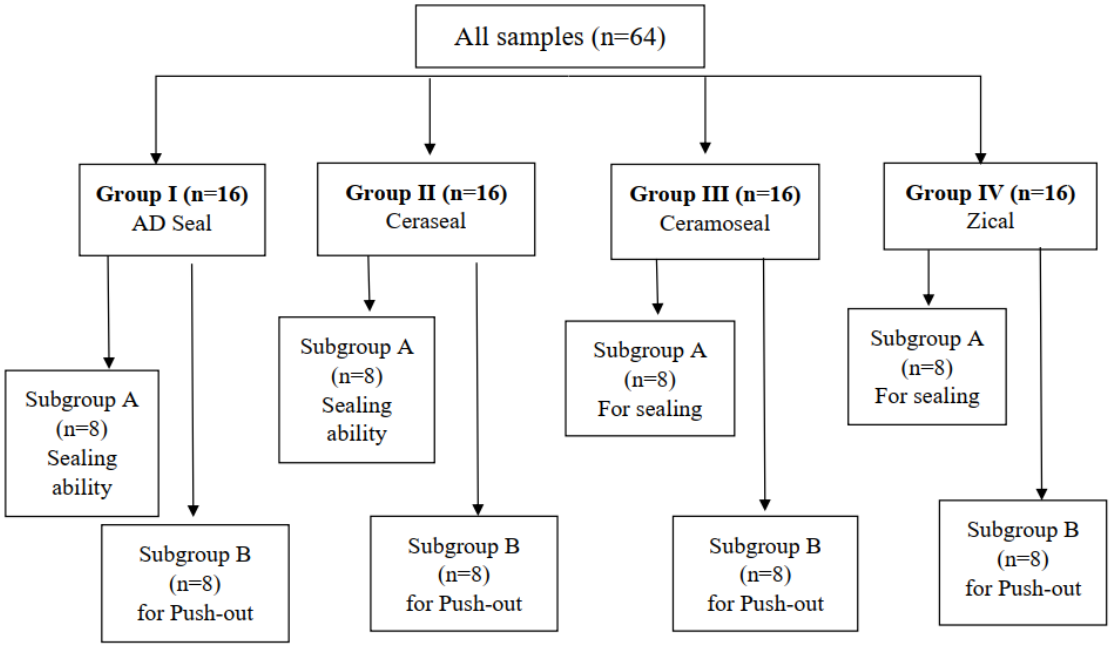

Figure 1: Samples classification.

Figure 2: ADseal sealer.

Figure 3: CeraSeal sealer.

Figure 4: Ceramoseal sealer.

Figure 5: Zical sealer.

Obturation step

Samples were obturated using cold lateral condensation technique. Master gutta-percha cone size 50.2% was coated with sealer and seated with tug back. Gutta-percha then was lateral condensed by spreader. The canal then was coated with sealer. Excess obturation material was removed at the orifice after compaction.

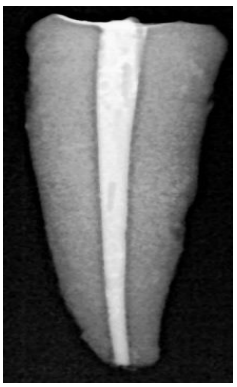

Figure 6: Obturated premolar root.

Group I (n=16): Samples were obturated using ADseal sealer.

Group II (n=16): Samples were obturated using CeraSeal sealer.

Group III (n=16): Samples were obturated using Ceramoseal sealer.

Group IV (n=16): Samples were obturated using Zinc-oxide based sealer (Zical).

Method of evaluation

Subgroup A was evaluated for sealing ability using fluid filtration technique, subgroup B was evaluated for push-out bond strength using universal machine.

A. Sealing ability

Subgroup A: fluid filtration technique evaluated the passage of liquid through the samples in order to assess the sealing ability of that case. This is done by measuring the bubble displacement which is produced on the path of liquid movement. In order to make the liquid move and assessing the leakage, there was an oxygen gas pressure behind the liquid, which was kept constant

throughout the experiment on 0.5 atm using a manometer.

A small air bubble was inserted into a 0.1 mL pipette with a syringe. The bubble must include the whole internal diameter of pipette in order to be sure that the bubble displacement is a trustful sign of liquid passage through the tube. First, the positive control group's samples were attached to the system and rapid movement of the bubble was noticed from beginning to the end of the pipette. Then, negative control group's samples were attached, and no bubble movement was observed in 8 min.

The system was ready for use after passing these 2 tests. A 10-megapixel digital Camera (Canon powershot G 11, Japan) and Adobe Photoshop 7.0 software (Adobe Systems Inc., San Jose, USA) were used to record and analyze the bubble movement.

The system regarding after one day and one week was allowed to equilibrate for 30 s before measuring the bubble movement. Afterward, the first picture was taken from the initial position of the bubble in pipette. After the computation, the amount of the fluid passing through the samples was calculated in µl/min after one day and one week. **(Figure 7).**

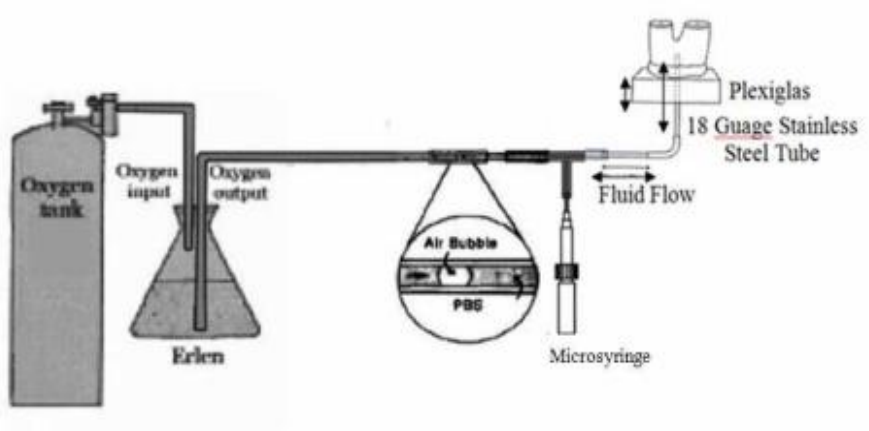

Figure 7: Fluid filtration device.

B. Push-Out bond strength

Subgroup B Teeth were embedded in chemical cured acrylic resin and then cross-sectioned using IsoMet 4000 microsaw Buehler USA mounting diamond disk 0.6 mm thickness at speed 2500 rpm and feeding rate 10 mm/min under water cooling. 2mm thick slices of apical-root portion for assessment of push out bond strength. Apical and coronal aspects of each sample were photographed and examined using stereomicroscope (Nikon MA100 Japan) confirm absence of dentin cracks or voids of the filling materials.

The filling material was then loaded with a 0.9 mm diameter stainless steel plunger selected. The plunger was mounted on the upper part of a universal testing machine (Instron universal testing machine model 3345 England data recorded using computer software Bluehill 3 version 3.3). The samples were aligned over a support jig in an apical to coronal direction to avoid any constriction interference. The tests were conducted at a cross head speed of 0.5 min-1 using a 500N load cell. The highest value recorded was taken as the push-out bond strength as shown in **(Figure 8)**

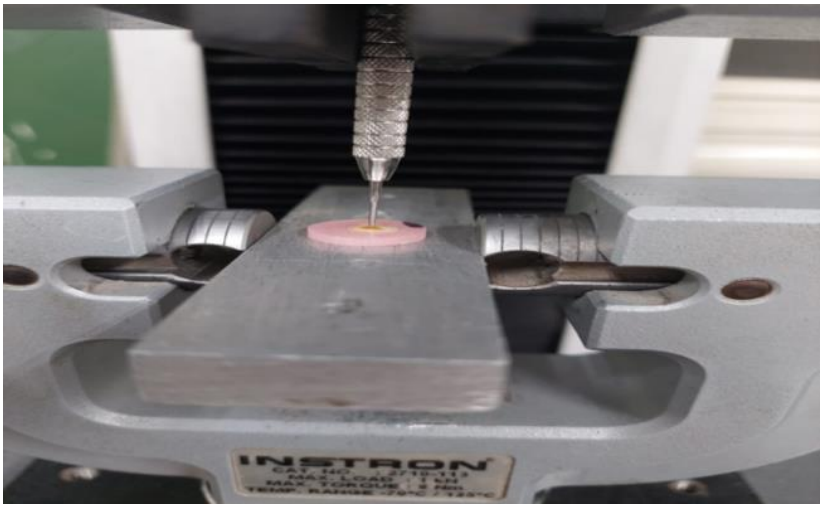

Figure 8: Cutting machine Ismot 4000 saw Buehler USA.

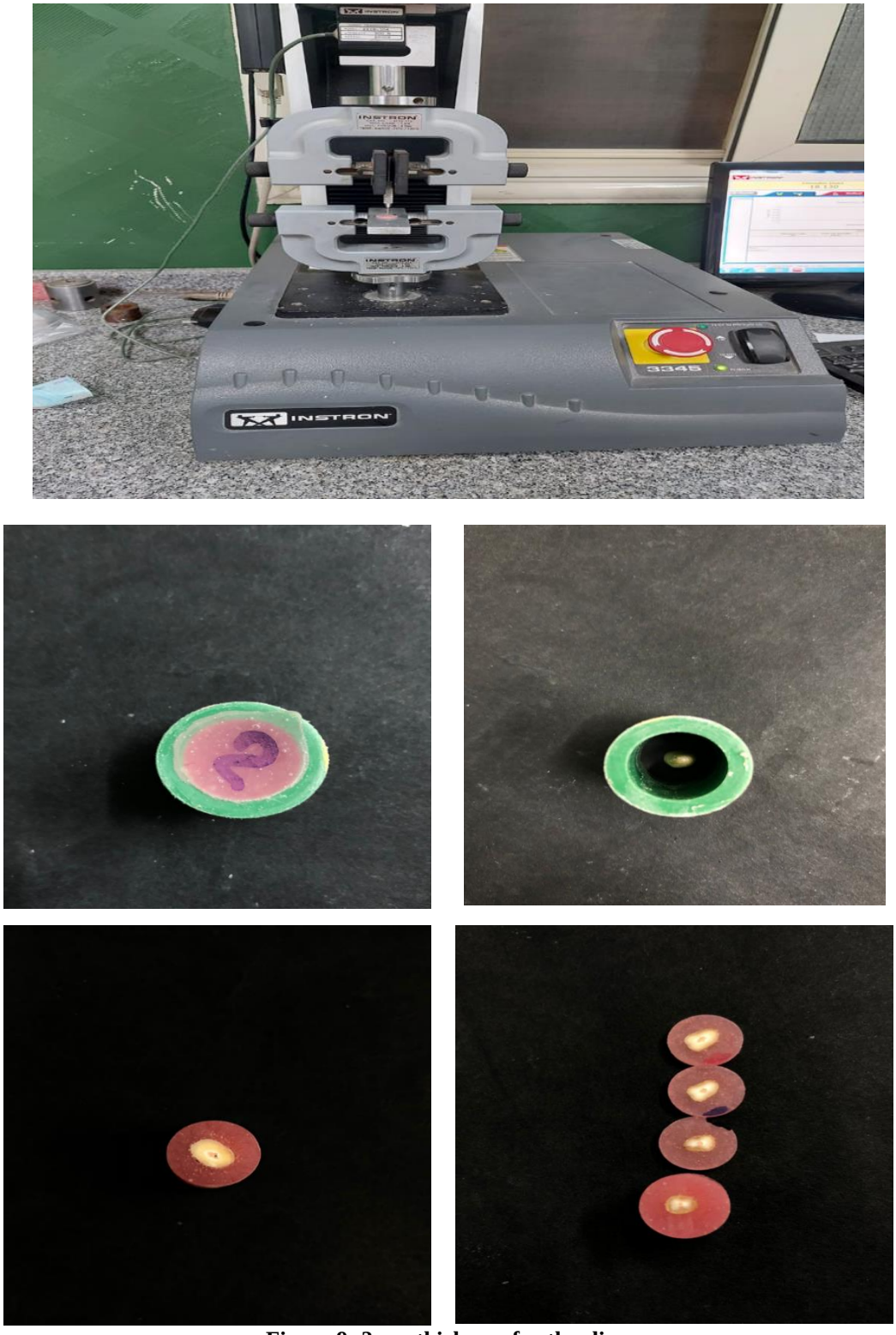

Figure 9: 2mm thickness for the slice.

The push-out value in MPa was calculated from force (N) divided by area in mm^2. After the push-out test, the samples were examined exhaustively to identify the modes of failure under a stereomicroscope under magnification. The failures were classified according to **Skidmore et al.**[13] as type I (adhesive failure at the sealer-dentin interface), type II (cohesive failure within the sealer or dentin), or type III (mixed failure in both the sealer and dentin).

Figure 10: Mounting diamond disc 0.6mm thickness at speed 2500rpm.

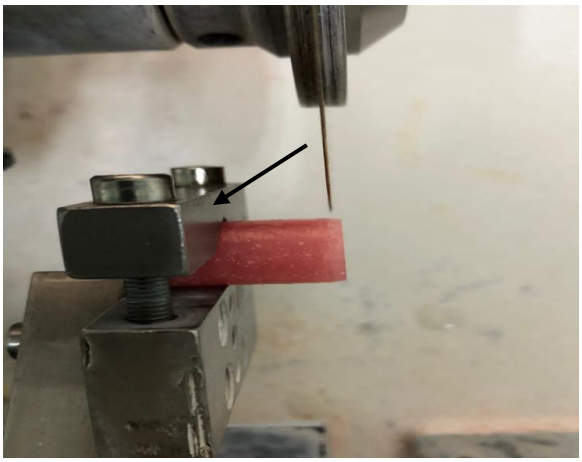

Figure 11: Stainless steel plunger with 0.9mm diameter.

Statical analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Quantitative variables were presented as mean and standard deviation (SD) and compared between the four groups utilizing ANOVA (F) test with post hoc test (Tukey). Qualitative variables were presented as frequency and percentage (%) and were analyzed utilizing the Chi-square test. A two tailed P value < 0.05 was considered statistically significant.

RESULTS

Table 1: Effect of sealer type on sealing ability.

	1 day	1 week
ADSeal	0.00250 ±0.005 [a]	0.00250 ±0.005 [a]
Ceraseal	0.00250 ±0.005 [a]	0.00250 ±0.005 [a]
Ceramoseal	0.00250 ±0.005 [a]	0.00250 ±0.005 [a]
Zical	0.00250 ±0.005 [a]	0.00150±0.001[a]
P-Value	1	0.437

Data presented as mean ±SD.
P ≤0.05

There was no significant difference among the studied groups at 1 day (P value=1). There was no significant difference among the studied groups at 1 week (P value=0.437).

Table 2: The effect of time on sealing ability.

	1 day	1 week	P-Value
ADSeal	0.00250 ±0.005 [a]	0.00250 ±0.005[a]	1
Ceraseal	0.00250 ±0.005 [a]	0.00250 ±0.005 [a]	1
Ceramoseal	0.00250 ±0.005 [a]	0.00250 ±0.005 [a]	1
Zical	0.00250 ±0.005 a	0.00150±0.001[a]	0.344

P ≤0.05

In the different sealing types, the mean (±SD) was 0.00250 ± 0.005 at one day and 0.00250 ±0.005 at one week at all studied groups. There was no significant difference at 1 day and 1 week in ADseal sealer group (P value=1). There was no significant difference at 1 day and 1 week in Ceraseal sealer group (P value=1). There was no significant difference at 1 day and 1 week in Ceramoseal sealer group (P value=1). There was no significant difference at 1 day and 1 week in Zical sealer group (P value=1).

Table 3: The effect of sealers on bond strength.

	Coronal	Middle	Apical
ADSeal	4.944 ±1.743 [a]	7.096 ±0.336 [a]	8.988 ±2.971 [a]
Ceraseal	4.645 ±0.637 [a]	5.231 ±2.081 [a]	10.705 ±2.060 [a]
Ceramoseal	3.688 ±0.592 [a]	4.434 ±2.557 [a]	3.876 ±1.580 [a]
Zical	3.818 ±1.038 [a]	3.362 ±2.142 [a]	2.105 ±1.814 [a]
P-Value	0.481	0.146	0.770

Data presented as mean ±SD; P ≤0.05

Regarding bond strength, at coronal section, the mean (±SD) was 4.944 ±1.743 in ADseal, 4.645 ±0.637in Ceraseal, 3.688 ±0.592 in Ceramoseal, and 3.818 ±1.038 in Zical. At middle section, the mean (±SD) was 7.096 ±0.336 in ADseal, 5.231 ± 2.081 in Ceraseal, 4.434 ±2.557 in Ceramoseal, and 3.362 ±2.142 in Zical. At apical section, the mean (±SD) was 8.988 ±2.971 in ADseal, 10.705 ± 2.060 in Ceraseal, 3.876 ±1.580 in Ceramoseal, and 2.105 ±1.814 in Zical. There was no significant difference at corneal section between ADseal, Ceraseal, Ceramoseal, and Zical (P value=0.481). There was no significant difference at middle section between ADseal, Ceraseal, Ceramoseal, and Zical (P value=0.146), and apical section between ADseal, Ceraseal, Ceramoseal, and Zical group (P value=0.770).

Table 4: The effect of time on push out.

	Coronal	Middle	-Apical	P-Value
ADseal	4.944 ±1.743 [a]	7.096 ±0.336 [a]	8.988 ±2.971 [a]	0.105
Ceraseal	4.645 ±0.637 [a]	5.231 ±2.081 [a]	10.705 ±2.060 [a]	1
Ceramoseal	3.688 ±0.592 [a]	4.434 ±2.557 [a]	3.876 ±1.580 [a]	0.866
Zical	3.818 ±1.038 [a]	3.362 ±2.142 [a]	2.105 ±1.814 [a]	0.401

Data presented as mean ±SD
P ≤0.05

There was no significant difference between corneal section, middle and apical section at ADSeal, Ceraseal, Ceramoseal, and Zical (P value=0.105, 1, 0.866, and 0.401 respectively).

DISCUSSION

The success of the endodontic obturation depends not only on an effective mechanical debridement of the root canal, but also on the level and quality of the obturation, which can be influenced by the type of material used, the technique applied, and by factors inherent to the preparation of the canal, such as the correct determination of the working length.[1]

The main targets of endodontic therapy are proper cleaning and shaping and three dimensional obturation of the root-canal system. The most widely used and accepted obturation material is the gutta percha. It is well known by its biocompatibility, inertness, dimensional stability and ease of removal for post placement or retreatment.[14]

Many studies demonstrated that there is a direct relationship between the quality of root canal obturation and treatment success[13] Failure of achievement of strong bond between root canal walls and filling materials may lead to bacterial infusion towards the apical third of the root causing apical periodontitis.[15]

The essential factors for successful endodontic treatment are proper cleaning and shaping of the root canals and the creation by the filling materials of a single block configuration in the canal space. Because of the poor adhesiveness of gutta-percha to root canal walls, the use of sealers has been considered mandatory.[16]

The characteristics of the material as well as the type of obturation technique used may affect the obturation quality. Obtaining a hermetic seal of root canal is the main goal of obturation. It is the function of gutta percha and root canal sealers.[17]

The main functions of root canal sealers are sealing off any voids and accessory canals, forming a bond between all the interfaces of root canal obturation which are the core of filling material and the canal walls. Achieving a hermetic seal is one of the most important goals in root canal treatment. Also, to form a bond between the root filling material and the canal walls. That's why, there is a continuous improvement in root canal filling materials

and bioceramic materials are now becoming widely used.[3]

This study was designed to compare the sealing ability and bond strength of CeraSeal Bioceramic sealer, Ceramoseal Bioceramic premixed with MTA, epoxy resin-based sealer, and zinc-Oxide based sealer.

We decided to discuss the sealing ability and bone strength of these sealers as they are usually used in our daily routine endodontic treatments- and to do hermetic sealer to do that.

In the current study, both AD and bioceramic sealers were used and both shown effectiveness. The AD sealer, classified as a resin sealer, exhibited the ability to penetrate the dentinal tubules extensively and exert substantial force during application and push out hardly. However, the efficacy of bioceramic sealers relies on hydration reactions during the setting process, enabling them to expand and effectively occupy the whole root canal space while exerting significant force make it hard to push out. Also, Elfaramawy et al.[18] used Ceraseal (bio-ceramic sealer.) and AD seal (Resin based sealer) and Zinc oxide and eugenol in their study. Moreover, AL-Haddad et al.[19] suggested the use of Bioceramic-based sealers.

Also, the zinc oxide sealer was selected due to its shown efficacy in successful sealing, as documented **Javidi et al.**[20] however, it exhibited a limited adhesion to the canal wall, leading to an easly push out.

The CeraSeal Bioceramic sealer, which is manufactured by Meta-company, is a widely used product with global usage. It offers the advantage of expansion during the setting process, allowing for effective filling of canal gaps.

Ceramoseal Bioceramic premixed with MTA, this addition has enhanced its suitability for instances with periapical pathosis. This combination combines the advantages of a bioceramic sealer, which effectively fills gaps in the canals after setting, with the antibacterial and repairing properties of MTA.

AD- sealers are resin based sealers that have been extensively studied in the literature due to their ability to establish a greater seal between the canal walls and gaps. This body of research is very relevant to our investigation. On the other hand, Zinc oxide sealer considered as the gold standard sealer. A prevoiuous study recommended that the root canal sealers based on epoxy resin are widely used because of their good physicochemical and adhesion properties.[21]

The sealer ability could be evaluated using different methods including the fluid filtration method that is used quantitatively to evaluate the micro-leakage in the obturated canals. It measures the amount of micro-leakage in microliters per minute. The method is developed by Derkson and modified by Shaikh.[22]

In our study, we separated between sodium and EDTA to avoid perceptations as their combinig leading to formation of colored sediments.

All teeth were prepared up to 35 6% and manual k-file size 50 to assure reaching irrigation solutions to Apex. That was also reported by Haapasalo et al.[23] who recommended size of 40 or more.

We used extracted teeth since they are morally preferable for conducting the test, as it is not possible to do such experiments on human subjects.

Bond strength of endodontic sealers to dentin is an essential property because it reduces the risk of disengagement of filling material from dentin during restorative procedures or the masticatory function, making sure that sealing is maintained and thus the clinical success of endodontic treatment.[22]

The present study used ADseal is an epoxy resin-based sealer due to their excellent physicochemical properties and sealing ability. According to manufacturer instructions and ISO 6876:1986, its working time is 35 mins after mixing and setting time of 45 mins. These properties are responsible for its superiority over the other epoxy resin sealers. It also characterized by resorption resistance and dimensional stability. Some authors reported increase of mass of epoxy resin-based sealers (compared to their initial dimension) due to water absorption.[24]

In accordance with our study, **Kumar et al. (2013)**[23] reported that resin sealers (ADseal) can produce strong and rigid cross-linked polymer with dentin collagen responsible for their sealing ability.

In our study, there was no significant difference regarding the effect of different sealer on sealing ability among the studied groups at 1 day (P value=1) and after 1 week (P value=0.437) that was in consistent with **Baras et al. (2019)**[25] who showed no statistically significant difference in solubility values of different sealers at 4 weeks. Similarly, **Song et al. (2016)**[27] revealed that all the tested sealers showed similar sealing ability although ADseal showed more microleakage than the others.

In the present study, resin-based endodontic sealers (AH-26 and ADseal) did not show better seal than ZOE-based sealer (Endofill). **Helvacioglu-Yigita et al. (2012)**[28] reported comparable results that the sealers leak to some extent, and most leakage occurs between the root canal walls and the sealer, but its use was found to significantly reduce apical leakage.

In contrast, **Fonseca et al. (2019)**[29] found that AH-Plus showed much better sealing ability compared to ZOE-based sealer.

This can be attributed to the fact that in our study the samples were stored at 37°C and 100% humidity similar to human body. Also, it may be due to the different components of AH-Plus compared to other resin-based sealers like AH-26 and ADseal.

Phukan et al. (2017)[30] believed that for good adhesion the adherent surface should be clean and smooth to enable intimate contact between it and the adhesive.

The present investigation does not support this idea, as the highest adhesive strength resulted when the smear layer was removed. Scanning electron micro-graphs revealed that smear layer removal exposed the dentinal tubules, creating a much more irregular surface, compared with those samples where the smear layer was left intact.

Consistent with our results, **Phukan et al. (2017)**[30] did not report specific values for these sealers; they simply classified their adhesive strengths to be "nil."'

This may be attributed to their using a constant crosshead speed of 10 mm per min rather than 1 mm per minute, at which we found the adhesive strength of Sultan to be 6.22 kg/cm^2 with the smear layer present and 7.23 kg/cm^2 without the smear layer. The ZnO and eugenol sealers may not be able to withstand any tensile load which is initiated at this high rate. In addition, the slight variation in constituents, or percentage of specific constituents, between ZnO and eugenol sealers may also be attributed to this difference, as only the exact sealers can accurately be compared between studies.[31]

The present study also used the bioceramic sealers that have been reported to induce, in vitro, the production of osteogenic and angiogenic growth factors by human periodontal ligament cells and have lower cytotoxicity than other conventional root canal sealers and may induce hard tissue deposition. Bioceramic sealers also have antimicrobial activity. The bioceramic sealers are mainly formed by a powder of tricalcium silicate, zirconium oxide, and povidone while the liquid is an aqueous solution of polycarboxylate and calcium chloride. Bioceramic sealers are inductive materials, this means that during hardening, when they come in contact with tissue fluids, calcium hydroxide reacts with phosphatase enzymes resulting in the formation of hydroxyapatite.[32]

In addition, we used the CeraSeal (Meta Biomed Co., Ltd. Korea, Republic) which is a new bioceramic sealer was used. It is in the form of a flowable paste that can be immediately applied inside the root canal. The manufacturers claim that it has a unique stability; never shrink or expand. Moreover, they claim that it has excellent sealing ability so, the single cone technique obturation can be performed.[33]

In line with our study, **Pontoriero et al.,**[34] found that there were no statistically significant differences in the sealing ability of the different types of cement at the apex.

In this study, although root canals were dried with paper points after being cleaned and washed, all samples showed completely set bioceramic sealers.

This can be due to the intrinsic humidity of root canal dentin that is sufficient to hydrate the sealer.[26] However, to date, bioceramic sealers are considered an advantageous technology in endodontics and they are revolutionizing the former endodontic principles that favored more gutta-percha at the expense of a very thin film of cement.[29]

The sealing ability of a sealer is linked to its solubility and to its bonding to the gutta-percha cone to the dentin. Several studies have evaluated the sealing abilities of various bioceramic sealers in vitro.[25,35] Regardless of the several methods used, the sealing ability of bioceramic sealers has been found to be satisfactory, and similar to that of other commercially available types of cement.

In contrast with our results, **Yousra Aly and Sherif El Shershaby**[36] who found that the bioceramic sealer Ceraseal combined with Bio GP Points showed a significantly higher bond strength than single cone AH Plus in coronal, middle and apical thirds.

In addition, ZnO has interesting antibacterial properties. Because of interesting antibacterial properties of ZnO, its powder can be used for dental applications as a sealer. In addition, ZOE-based cements have been found to possess favorable characteristics in terms of biocompatibility. These were the reasons for selecting ZnO as the base of a nano-sealer in the present study.

The use of nano-structured materials as sealers in root canal therapy is limited to two or three types of nano-structured hydroxyapatite alone or in combination with epoxy resin (Nanoseal). Properties like antimicrobial activity, radiopacity, flow, film thickness and cytotoxicity have been evaluated in various studies.[34,37] We could not find any published reports on sealing ability of nanomaterials as sealer in root canal therapy to make comparisons.

In **Maryam Javidi**[20] showed that synthesized ZnO nano-powders exhibited less microleakage in comparison with AH26 and ZOE, making them suitable for use as a nano-sealer in root canal treatment.

Moreover, **Dabaj et al. (2018)**[38] found that a calcium silicate sealer showed a lower bond strength with the

thermo-plasticized injectable technique than when cold lateral condensation was used. Residual water in the tubular orifice can be evaporated by heat application, which could result in insufficient hydration. Therefore, calcium silicate-based sealers should be used with the single cone technique, as recommended in the manufacturer's manual. They also added that Heat can accelerate hydration and hydroxyapatite formation in calcium silicate-based root canal sealers. Faster setting times decrease flowability and result in lower bond strength of the calcium silicate-based sealer.

Similarly, **Patni et al. (2016)**[39] concluded that ZOE sealers demonstrate more microleakage than AH Plus.

Carneiro et al., (2012)[40] who concluded that considering the interaction effect between the technique and root filling material, AH plus sealer showed significantly higher bond strength to intra-radicular dentin when used with lateral condensation as compared to thermoplasticized technique, also Lateral compaction was associated with higher bond strengths of the materials to intra-radicular dentine than a hybrid technique using thermomechanical compaction. The greatest push-out strengths were obtained when the canals were filled with LC of AH Plus and GP cones.

In the present study, all teeth were prepared up to 35.6% and manual k-file size 50 as a master apical file. **Fidler et al. (2021)**[41] reported that for wider apical preparation, with up to size #35 file, involves increasing loss of flexibility, which results in greater canal displacement, particularly with stainless steel files.

The present study used the push out test as it is a reliable, reproducible and can be easily interpreted technique based on the shear stress at the interface between dentine and cement, which is comparable to stresses under clinical conditions.[22]

In our present study, there was no significant difference among the different sealers in sealing ability and push out test.

Similar to our results, **Veeramachaneni et al**. **(2022)**[42] observed that Bio C sealer and Dia-Proseal sealer exhibited greater push-out bond strength.

In agreement in our study**, Yigit et al. (2012)**[43] demonestrated that the sealers leak to some extent, and most leakage occurs between the root canal walls and the sealer, but its use was found to significantly reduce apical leakage.

Also, **Mokhtari et al., (2015)**[24] found that no significant difference in prevention of apical microleakage among the three sealers.

In agreement with our results, **Al-Haddad et al. (2016)**[19] demonstrated the sealing ability of Bioceramic based root canal sealers and mentioned that by obtaining the hybrid layer, all communications between the exterior and the radicular canal are eliminated, realizing a complete seal of the dentinal wound.

Moreover, **Madhuri et al., (2016)**[44] revealed that the push-out bond strength of Bioceramic sealer was highest followed by resin-based sealer and lowest bond strength was observed in MTA-based sealer.

Also, **Shokouhinejad et al. (2012)**[45] reported that the presence of PBS in the root canals increased the bond strength values of EndoSequence BC sealer/gutta-percha after 1 week. Whereas no difference was found between the bond strength of EndoSequence BC sealer/guttapercha in the presence or absence of PBS in the root canals after 2 months.

In the same context, **Shokouhinejad et al. (2012)**[45] compared the bond strength of a bioceramic sealer (Bioceramic Sealer) and AH Plus based on the smear layer presence or absence. Extracted single-rooted human teeth were instrumented each underwent irrigation by 5.25% NaOCl and smear layer was not removed; or the root canals were finally irrigated with 17% EDTA and 5.25% NaOCl to remove the smear layer.

Regarding our study results showed that sealing ability and push out bond strength are strongly correlated with each other.

All sealers showed relatively good results: ADseal as being resin sealer, enter the dentinal tubules so making good sealing with difficulty to be pushed out. Also, bio ceramics depend on hydration reaction in setting, filling the entire canal, so making a good seal with difficulty to be pushed out after setting. On the other hand Zinc oxide may be have an ability to make good sealing, However it can be easily pushed out of the canal.

CONCLUSION

From the findings of this in vitro study, the following conclusions can be drawn under the sealing ability was comparable between ADSeal, Ceraseal, Ceramoseal and Zical sealer in 1day and 1 week, the push out technique was comparable between ADSeal, Ceraseal, Ceramoseal and Zical sealer in 1day and 1 week, sealing ability and push out bond strength are strongly correlated with each other.

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