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EVALUATION OF CALCIUM HYDROXIDE'S EFFECT ON THE BOND STRENGTH OF CERASEAL SEALER TO RADICULAR DENTINE USING PUSH-OUT TEST

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ABSTRACT

Aim: The objective of this study was to evaluate the impact of calcium hydroxide ($Ca(OH)_2$) as an intracanal medicament on the strength of the bond of Ceraseal bioceramic sealer to root canal dentine.

Materials and methods: Twenty extracted human canines were decoronated to obtain standardized root length. Teeth were prepared using Protaper Next rotary files up to the X4 file. Then randomly they were allocated into two groups as follows (each group contains 10 samples): group A(the control group: no intracanal medication), group B ($Ca(OH)_2$) intracanal medicament was used). $Ca(OH)_2$ was removed by irrigation and activation after 7 days. Lateral compaction technique was used for obturation with Ceraseal sealer. After two weeks in the incubator, a universal testing machine was used for the push-out bond strength(POBS) test. Data were gathered and analyzed statistically by one-way ANOVA test followed by post hoc Tukey at a significance level ($p < 0.05$).

Results :A statistically significant difference in bond strength was observed between the control and $Ca(OH)_2$ groups in both the coronal and apical regions ($p < 0.005$), with the control group exhibiting the highest bond strength values.

Conclusion: The bond strength of Ceraseal sealer was reduced in all thirds of the canal as a result of the prior application of $Ca(OH)_2$ as intracanal medication.

KEY WORDS: Ceraseal Bioceramic sealer, Calcium hydroxide, bond strength, Push out.

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INTRODUCTION

Effective root canal treatment requires proper instrumentation, thorough disinfection, and three-dimensional obturation to achieve a durable hermetic seal that prevents reinfection and microleakage [1]. Since gutta-percha does not bond to dentin, sealers are essential for long-term sealing, with strong adhesion critical to resist functional stresses and restorative procedures [2]. However, irrigating solutions and intracanal medicaments can reduce bond strength by leaving residues on canal walls, which hinder sealer penetration into dentinal tubules, weaken the adhesive interface, and increase the risk of microleakage and treatment failure [3].

Calcium silicate–based sealers have been developed as a promising alternative to traditional sealers due to their excellent biocompatibility and bioactive properties [4]. They can penetrate dentinal tubules and interact with dentin moisture to form a stable bond with both the dentin and the core filling material, reducing shrinkage and maintaining dimensional stability [5]. In addition, they release bioactive compounds at the sealer–dentin interface that promote tag-like structures, enhancing adhesion. These sealers facilitate the development of a secondary monoblock in combination with gutta-percha, hence enhancing the integrity and strength of the root canal system [6,7].

Among the newly developed bioceramic sealers, CeraSeal (Meta Biomed Co., Korea) is a ready-to-use, flowable bioceramic sealer designed to chemically bond with dentin, providing a reliable seal between root canal walls and filling materials [8] . According to the manufacturer, It offers high dimensional stability without shrinkage or expansion, along with hydrophilicity, radiopacity, and strong push-out bond strength [6,9]. However, limited data are available regarding its interaction with various intracanal medicaments.

Chemomechanical preparation is a fundamental step in root canal therapy, yet no single technique can completely disinfect the canal system[13]. Therefore, $Ca(OH)_2$ is often recommended as an intracanal medicament between endodontic treatment visits due to its strong antibacterial action and favorable biological properties, making it one of the most widely used options in endodontics .[10–12]

However, several studies have demonstrated that total elimination of $Ca(OH)_2$ from the root canal is extremely difficult, whatever the technique employed. [5,13] Residual traces of the material have been reported to hinder the sealer's infiltration into dentinal tubules and may interfere with the sealer, adversely affecting the bonding strength of sealers to dentin. [14,15] These remnants can compromise the integrity of the obturation by increasing the risk of obturating material dislodgment, bacterial recontamination, and fluid leakage through both coronal and apical routes.[16–18]

Given these concerns, this study is designed to investigate the effect of [$Ca(OH)_2$] as an intracanal medicament on the strength of the bond of Ceraseal sealer to radicular dentine, assessed through the POBS test**.**

MATERIALS AND METHODS

This study received approval from the Research Ethical Committee of Faculty of Dentistry, Mansoura University (under a protocol ID: A01012023). The Declaration of Helsinki's ethical principles were adhered to throughout all procedures.

Teeth selection

Twenty freshly extracted human canines were collected from the department of Surgery. Teeth were extracted for periodontal indications, and prior to the procedure, patients were informed. Periapical radiographs were obtained to verify that the teeth matched the established inclusion criteria: Roots exhibiting a single, straight canal with fully formed apices and patent foramina. Teeth exhibiting one of the following criteria were excluded: detectable carious lesions, root resorption, cracks, prior root canal trartment or calcification. The samples that were chosen were thoroughly cleaned to remove both soft and firm debris using a periodontal scaler (Woodpecker) and disinfected by 5.25% NaOCl for one hour, then stored in Chloramine-T solution at room temperature [19].

Teeth Preparation

All specimens were horizontally sectioned at the cementoenamel junction (CEJ) using a carbide bur in high-speed under continuous water coolant standardized root segments measuring 16 mm in length [20] . The canal patency was confirmed with a size 10 stainless steel K-file (Mani, Utsunomiya, Tochigi, Japan) was introduced into the canal. To determine the working length(W.L) a # 15 K-file (Mani, Utsunomiya, Tochigi, Japan)was inserted into the root canal until its tip was visible at the apical foramen, then a 1mm was deducted from the predetermined length. A radiograph was subsequently performed to confirm the accuracy of the W.L. preparation of the canal was done using Protaper Next Rotary system (Dentsply Sirona, Charlotte NC, USA) up to X4 (40/0.06) file and irrigated after the usage of each file by 5 mL of sodium hypochlorite (NaOCL) 2.5%. After instrumentation completion, 5 mL of Ethylenediaminetetraacetic acid (EDTA) 17% used to irrigate the canals for 1 min. samples were allocated into 2 groups. Each consists of 10 samples as follow:

- Group A (control group): No intracanal medication**.**
- Group B **:** intracanal medicament [$Ca(OH)_2$] powder was used.

Paper points size #40 (Meta Biomed, Cheongju, Korea) were used to dry the canals. $Ca(OH)_2$ was placed using a lentulospiral (Mani,INC,Japan). The samples were sealed using sterile cotton pellet and Cavit (ESPE, Seefeld, Germany). Samples were maintained at 37°C with a 100% humidity condition in an incubator for one week. After that the temporary restoration was removed. The intracanal medicaments were eliminated using a sequence of 5 ml NaOCL, 5ml saline, followed by 5 mL of 17% (EDTA) (Prevest, Jammu, India), activated with EDDY tips (VDW, Munich, Germany) for 60 seconds per canal finally the canals were flushed by 5 ml saline solution [21]. Paper points (Meta Biomed, Cheongju, Korea) size #40 were used to dry All root canals. Obturation was performed using the lateral compaction technique with CeraSeal bioceramic sealer. A Size (40/0.04) gutta-percha cones were used as master cones, and radiographs were taken to confirm appropriate master cone selection. Ceraseal, a premixed sealer, was delivered using the system syringe with an applicator tip placed 2 mm shorter than the working W.L. A size #30 spreader was used with accessory G.P. cones (size 25/0.02) until the canal is completely filled. A heated hand plugger (Fanta, China) was employed to remove excess gutta-percha. In order to seal all samples, Cavit was used, and then they were incubated at 100% humidity for two weeks and at 37°C to ensure obturating materials are completely set.

POBS test

Roots were embedded in chemically cured acrylic resin. Horizontal sections, 2 mm thick that confirmed by digital caliper, were prepared at the coronal, middle, and apical levels using a water-cooled IsoMet 4000 microsaw. Each section was mounted on a customized metallic jig with a central cavity to allow unobstructed displacement of the filling material. The apical side of each specimen faced upward to enable apico-coronal force application and reduce canal taper interference [22].

A stainless steel plunger of varying diameters, matching the canal size, was used to apply compressive force directly to the obturation material. The plunger was attached to a universal testing machine (Instron Model 3345, England) operated with Bluehill 3 software (version 3.3) at a constant crosshead speed of 0.5 mm/min to ensure precision and consistency. A calibrated load cell recorded the maximum load in newtons, which was then converted to megapascals (MPa) using the designated formula.

Push-out bond strength (MPa) = Maximum load (N) / area under load (mm^2)

Stastical analysis

Statistical analysis was performed using GraphPad Prism software (version 10.0; GraphPad Software Inc., San Diego, CA, USA). Intergroup differences were assessed using the independent t-test, while intra-group comparisons among the three thirds were analyzed via one-way ANOVA, followed by Tukey's post hoc test to determine pairwise significance.

RESULTS

The bond strength values (in MPa) for both the control and $Ca(OH)_2$ groups across the different root regions are presented in Table 1.

TABLE (1) The Mean value± Standard deviation of group A and B for push-out strength [MPa] across various surfaces.

Surface	Control	$Ca(OH)_2$	Test of significance
Coronal	$4.97±2.2^{Aa}$	$2.02±1.19^{Ba}$	t = 3.73 P = 0.001
Middle	$4.88±1.88^{Aa}$	$3.23±2.82^{Aa}$	t = 1.54 P = 0.14
Apical	$5.03±1.16^{Aa}$	$3.66±0.95^{Ba}$	t = 2.89 P = 0.0098
P value	P= 0.981	P= 0.14	

Different capitals in the same row denote a significant difference between different groups.

Different small letters in the same column denote a significant difference within the same group.

Intergroup comparison

Statistical analysis indicated a significant difference in bond strength between the control and calcium hydroxide [$Ca(OH)_2$] groups in both the coronal and apical regions ($p < 0.005$), whereas no statistically significant difference was found in the middle third, as presented in Table 1.

Intragroup comparison

The study had shown that the apical region exhibits higher bond strength than the other two regions, with no significance between different regions in the same group.

DISCUSSION

Endodontic treatment's effectiveness is reliant on the root canal's disinfection, eradicating bacteria and preventing reinfection, as microbial presence is the main cause of periapical lesions and treatment failure.[23] The chemomechanical preparation alone is frequently insufficient to eradicate all bacteria due to the resilient nature of microbial biofilms and the complex anatomy of the canal. Therefore, using intracanal medicaments has become essential to enhance the disinfection [24].

$Ca(OH)_2$ was used in this study due to its long-standing and widespread use in endodontic practice. It is regarded as the gold standard intracanal medicament for its biocompatibility, antibacterial activity, tissue-dissolving capacity, and its ability to promote hard tissue formation. Moreover, $Ca(OH)_2$ has been shown to inactivate bacterial endotoxins both in vitro and in vivo, and it remains the only intracanal medicament currently proven to be clinically effective for endotoxin inactivation [25].

The success of root canal obturation relies on the ability of filling materials to adhere effectively to the canal walls under both static and dynamic conditions. Under static conditions, a reliable seal is essential to prevent fluid leakage between the dentin and the obturating material as well as microbial growth, thus reducing the risk of periapical pathology. Under dynamic conditions, strong adhesion enhances the resistance to displacement of the filling material. Since gutta-percha exhibits limited bonding to dentinal surfaces, the utilization of a sealer is indispensable for the establishment of a secure interface between the canal walls and the root filling, contributing to the overall structural strength of the tooth. Consequently, ongoing innovations in sealer formulations have aimed to enhance these adhesive properties [8].

In this study the POBS test was employed to assess the adhesion of endodontic sealers, as it represents a validated and common methodology for measuring interfacial bond strength between sealers and dentine [26]. This technique effectively stimulates functional dislodgment forces, such as those encountered during mastication or post-endodontic restorative procedures. this makes it an ideal examination for investigating the impact of the intracanal medicament on the sealer's bond strength to the root dentine [22]. Goracci et al. concluded that the push-out test is a highly reliable method, as it provides a clinically relevant assessment of the bonding efficacy of root canal sealers [27,28].

CeraSeal was selected in this study because it is considered a new promising bioceramic sealer. It establishes a bond with the dentine chemically by forming hydroxyapatite during its setting process through what is known as the "mineral infiltration zone," reflecting its micromechanical interaction. The sealer completes its setting without undergoing shrinkage by utilizing the moisture in the dentinal tubules, thus creating a tight, gap-free seal between obturation material and the dentine.

Furthermore, it offers advantages such as excellent biocompatibility, bioactivity, sealing ability, and Hydrophilic nature. It sets in a moist environment, unlike resin sealers, making it suitable for cases with residual moisture. Additionally, it penetrates the dentinal tubules effectively, promoting strong adaptation and a reliable hermetic seal[7,29].

The lateral compaction technique was chosen for obturation in this study to stimulate clinical conditions using sealer and gutta-percha and to create consistent sealer layers (50-150 μm) at the dentin interface, ensuring standardized conditions for material comparisons study which was in accordance with other studies [30–32].

The findings of this study demonstrated that $Ca(OH)_2$ adversely affected the bond strength when compared to the group that received no intracanal medicament. The weakening of the bond may be due to residual $Ca(OH)_2$ particles, which are challenging to eliminate entirely from the root canal, That may hinder sealer penetration and adhesion, Thus diminishing bond strength. [33,34] This result is consistent with those reported by ***Guiotti*** et al.[35] , ***Sahebi*** et al.[36], and ***Ghabraei*** et al.[18], where a significant reduction in bond strength is observed following $Ca(OH)_2$ application. These findings are inconsistent with earlier reports suggesting that $[Ca(OH)_2]$ has a favorable impact on the bonding properties of root canal calcium silicate based sealers[37,38].

A possible explanation for the lack of a significant difference in the bond strength of the middle third of samples between the tested groups may be attributed to the more uniform distribution of dentinal tubules and collagen fibers in this region, compared to the coronal and apical thirds[39,40]. This observation aligns with the findings reported by ***Guiotti*** et al.[35]

In this study, the bond strength increased progressively from the coronal to the apical region. These findings align with previous studies ***Sahebi*** et al [36], ***Cakici*** et al[41] . ***Guiotti*** et al.[35] ***Gaston*** et al. They reported similar results. This can be attributed to the narrower canal diameter apically, which increases frictional resistance. The thinner sealer layer resulting from the narrower root cross-section in this region may also play a role, as thicker layers are more prone to polymerization shrinkage and associated internal stresses that can compromise adhesion[40] .Furthermore, bond strength appears to be more influenced by the amount of solid dentin than by tubule density. In contrast, these results differ from earlier studies that documented a gradual reduction in bond strength from the coronal to the apical third of the root canal [42,43].

CONCLUSION

Based on the findings and within the limitations of the current study, the use of $Ca(OH)_2$ as an intracanal medicament was associated with a reduction in the bond strength of Ceraseal bioceramic sealer to radicular dentine.

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