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EFFECT OF CALCIUM HYDROXIDE INTRACANAL MEDICAMENT ON BOND STRENGTH OF AH PLUS AND BIOCERAMIC SEALER TO ROOT DENTINE

Yazeed M. Alshannaq* *and* Amany E. Badr**

ABSTRACT

Aim: To study the effect of calcium hydroxide as intracanal medicament on bond strength of AH Plus and Bioceramic sealer to root dentine.

Material and Methods: forty single-rooted human teeth were prepared by ProTaper Next. The samples were randomly allocated into two groups (n=20 teeth): the control group (no intracanal medicament) and Calcium hydroxide. After one week, the intracanal medicament was flushed out, and each group was further divided based on the sealer used AH Plus or Bio-C. Root canals were obturated using lateral compaction technique and incubated again for two weeks. The roots sectioned into 2 mm slices from the coronal, middle, and apical thirds. Push-out bond strength was measured. Results were recorded in MPa and statistically analyzed.

Result: Calcium hydroxide significantly reduced bond strength compared to control at the middle (AH Plus $p = .049$, Bio-C $p < .001$) and apical thirds (AH Plus $p = .048$, Bio-C $p < .001$). No significant differences were found at the coronal third.

Conclusion: Calcium hydroxide reduced the bond strength of both AH Plus and Bio-C sealers to root dentine.

KEYWORDS: Calcium hydroxide, AH Plus, Bio-C sealer, intracanal medicament, push-out bond strength.

* MSc, Department of Endodontics, Faculty of Dentistry, Mansoura University, Egypt.
** Professor of Endodontics, Department of Endodontics, Faculty of Dentistry, Mansoura University, Egypt.

INTRODUCTION

The primary objective of root canal treatment is the elimination of bacteria and their harmful metabolites from the infected teeth. This is typically achieved through a combination of mechanical instrumentation, chemical irrigation, and intracanal medicaments.[1] The bond between root canal walls and the filling material is established through the use of endodontic sealers. Ensuring a strong adhesive interface is vital to prevent reinfection, which often results from coronal or apical leakage caused by microbial invasion. [2]

For endodontic applications, resin-based sealers and adhesive systems have been introduced to improve the sealing quality of root canal fillings .[3] Effective adhesion to dentin is essential for a sealer to prevent bacterial leakage .[4] However, factors such as the type of irrigants and intracanal medicaments used can influence this bond, as they may interfere with the sealer's ability to achieve a proper seal .[4,5]

Over time, studies have shown that intracanal medicaments fulfill multiple clinical roles, including the management of dental trauma, periapical pathology, apexification, revascularization of immature teeth, and treatment of inflammatory root resorption. [6] Among these agents, calcium hydroxide (CH) is widely favored due to its potent antimicrobial activity and minimal toxicity. In aqueous environments, it dissociates into hydroxyl ions, which disrupt bacterial cell membranes, protein denaturation, and interfere with DNA integrity, ultimately leading to cell death. [6] CH is widely used as an intracanal medicament because of its potent antibacterial effect, attributed to its high alkalinity. Its elevated pH disrupts the structural and functional integrity of gram-negative bacterial cell walls by altering lipopolysaccharide components, impairing membrane transport, and ultimately leading to cell death. [7]

In root canal obturation, gutta-percha (GP) serves as the primary filling material, while a sealer fills the voids between the GP and canal walls to ensure a complete seal.[8] To achieve an effective seal and prevent bacterial leakage, the sealer must adhere well to both the GP and the dentinal walls.[9]

AH Plus (Dentsply, Konstanz/Germany) is a sealer that is made of epoxy resin and has been used popularly for its physical properties, low solubility and bonding ability to dentin [10], although having no bioactivity [11], it is still considered the benchmark sealer to which new sealers are compared .[12]

Bio-C Sealer (Angelus, Londrina, Paraná, Brazil) is a bioceramic sealer formulated with components such as calcium silicates, calcium aluminate, calcium oxide, zirconium oxide, iron oxide, silicon dioxide, and a dispersing agent. As per the manufacturer, it exhibits favorable clinical properties including biocompatibility, bioactivity, high alkalinity, good flowability, and sufficient radiopacity. [13]

Methods for testing bond strength are employed to evaluate how effectively endodontic materials adhere to tooth structures.[14]

The push-out bond strength (POBS) test measures the amount of force needed to displace a material from within the root canal. Accordingly, this in-vitro study was conducted to assess the influence of CH, used as an intracanal medicament, on the bond strength of endodontic sealers.

MATERIALS AND METHODS

The ethical Committee of faculty of dentistry, Mansuora University gave the study its approval ;(A0103024 RC)

Sample size calculation

The sample size was determined using G*Power software (version 3.1.9.7), (α = 0.05 and power of 0.80). For the calculation, t test was used with effect size of (1.78) based on the anticipated mean difference of the shear bond strength to dentine root after application of CH with two different sealers. The total sample size was 40.

Teeth selection

Forty freshly extracted, single-rooted human teeth were collected from Oral and maxillofacial Surgery Department in Faculty of Dentistry, Mansoura University.

The inclusion criteria for the study required teeth with a single, straight root and fully developed apices, free from any obstruction within the canal system. Selected teeth had to be free of caries, cracks, root resorption, and have no history of previous root canal treatment. Conversely, the exclusion criteria ruled out any teeth presenting with cracks, caries, restorations, resorptions, immature apices, multiple canals, or those that had undergone previous root canal treatment.

The selected teeth were cleaned mechanically to remove any soft tissue and hard tissue debris from the external root surface using ultrasonic.

Samples preparation and obturation

Teeth were decoronated with a high-speed diamond disk to obtain 14–16 mm root length. The working length was defined as 1 mm short of the length at which a #10 K-file was visible at the apical foramen. Canals were instrumented using Protaper next up to X 4 (Dentsply Maillefer, Ballaigues, Switzerland). During instrumentation, 3 ml of 5.25% solution were used for irrigation sodium hypochlorite using 30-gauge side vented irrigating needle between each file, after instrumentation 5 ml EDTA solution was used for smear layer removal and distilled water was used in between irrigating solutions and as a final flush.

Randomization and Group Assignment

The specimens were then allocated at random into two groups (n=20 per group) based on the type of intracanal medicament applied into; group 1 (No intracanal medicament) and group 2 (A paste was prepared by mixing CH powder with sterile saline in a 1:1 ratio).

CH was delivered into the canal using a lentulo spiral. The coronal access was then sealed, and the samples were incubated for one week.[15] Following incubation, the intracanal medicament was flushed out through irrigation.

Subgrouping was performed within each group based on the sealer used, as follows:

- **Subgroup A:** Root canals were filled using GP points and AH Plus sealer, utilizing lateral compaction technique.
- **Subgroup B:** Root canals were filled using GP points and Bio-C Sealer, also utilizing lateral compaction technique.

All samples were then sealed and incubated for two weeks .[16]

Method of Evaluation

Push out bond strength test

The teeth were embedded in chemically cured acrylic resin and sectioned using an IsoMet 4000 microsaw (Buehler, USA) equipped with a 0.6 mm thick diamond disk (Figure 1). Sectioning was performed at a speed of 2500 rpm and a feed rate of 10 mm/min under continuous water cooling, yielding 60 slices per group and a total of 120 slices across the experimental groups. Each slice (coronal , middle and apical) was measured for its coronal and apical diameter under stereomicroscope, then put under compressive load with a speed of 0.5mm/min using a 0.9 mm diameter cylindrical steel punch tip in a 500N load cell by a universal testing machine (Instron universal testing machine model 3345 England) (Figure 2) in which the punch tip was contacting only the filling material . In apical coronal direction the load was applied to avoid any obstruction until the root filling material was dislodged. The force of failure (N) was divided by the material-canal wall interface's surface area (mm2) to get each sample's POBS (MPa).

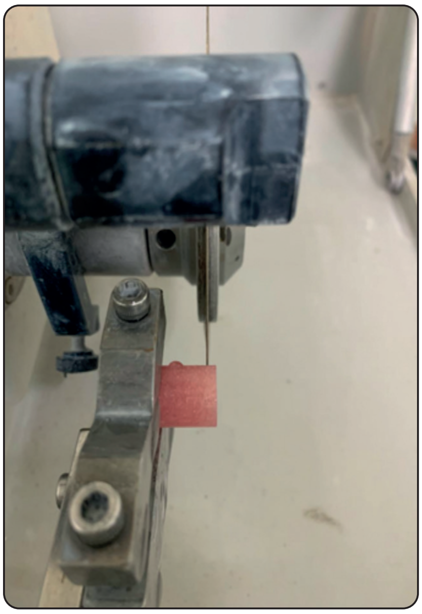

Fig. (1) Sectioning using an IsoMet 4000 microsaw (Buehler, USA).

Fig. (2). Universal testing machine -push

Statistical analysis

Data analysis was conducted using SPSS® v25. The data were tested for normality via the Shapiro–Wilk test. As data were parametric, Data are expressed as mean ± SD. A three-way ANOVA with Bonferroni post hoc tests evaluated differences across medicaments, sealers, and root canal thirds. Significance was set at $p < 0.05$.

RESULTS

The POBS values (in MPa) for both groups at different root levels are presented in Tables 1 and 2. CH led to a reduction in bond strength, particularly in the apical and middle thirds. In middle third, both AH Plus ($p = .049$) and Bio-C ($p < .001$) showed notable decreases. Similar reductions were observed in the apical third for AH Plus ($p = .048$) and Bio-C ($p < .001$). Although no difference was detected at the coronal third, values were still lower with CH, with the effect being more pronounced in Bio-C.

TABLE (1) Mean ± Standard deviation of push out strength [MPa] of AH Plus and Bio-C sealers at different regions.

Third	Medicament	AH Plus (Mean ± SD)	Bio-C (Mean ± SD)	p-value
Coronal	Control	$2.038^{a} \pm 0.787$	$1.760^{a} \pm 0.617$	.544
	Calcium Hydroxide	$1.293^{a} \pm 0.620$	$0.976^{a} \pm 0.141$	.488
Middle	Control	$2.557^{a} \pm 1.073$	$2.708^{a} \pm 1.053$	.742
	Calcium Hydroxide	$1.721^{b} \pm 0.698$	$0.752^{c} \pm 0.388$	.035*
Apical	Control	$3.680^{a} \pm 1.123$	$3.525^{a} \pm 1.263$	.734
	Calcium Hydroxide	$2.832^{b} \pm 1.620$	$1.037^{c} \pm 0.939$	<.001*

X; mean, SD; standard deviation; *p is significant at 5% level. Different letters in the same row showed a significant difference between each 2 sealers (Bonferroni test, p<.05).

TABLE (2) Mean ± Standard deviation of push out strength [MPa] of the control and calcium hydroxide groups at different regions.

Third	Sealer	Control (Mean ± SD)	Calcium Hydroxide (Mean ± SD)	p-value
Coronal	AH Plus	$2.038^{a} \pm 0.787$	$1.293^{a} \pm 0.620$	.105
	Bio-C	$1.760^{a} \pm 0.617$	$0.976^{a} \pm 0.141$	.088
Middle	AH Plus	$2.557^{a} \pm 1.073$	$1.721^{b} \pm 0.698$	.049*
	Bio-C	$2.708^{a} \pm 1.053$	$0.752^{c} \pm 0.388$	<.001*
Apical	AH Plus	$3.680^{a} \pm 1.123$	$2.832^{b} \pm 1.620$	.048*
	Bio-C	$3.525^{a} \pm 1.263$	$1.037^{c} \pm 0.939$	<.001*

X; mean, SD; standard deviation; *p is significant at 5% level. Different letters in the same row showed a significant difference between each 2 medicaments (Bonferroni test, p<.05).

DISCUSSION

A high-quality root canal filling should bond securely to the walls and withstand dislodgement forces .[18]This resistance helps prevent microleakage and supports the root structure .[19] The ability of root filling materials to resist dislodgement is measured through a POBS test .[17]

Intracanal medications are frequently suggested to eliminate any remaining bacteria in the root canal, dentinal tubules, accessory canals, and irregularities. They also help reduce periapical inflammation, promote healing in the periapical area, eliminate apical exudates, manage inflammatory root resorption, and prevent contamination of the canal between treatment sessions .[20]

The current study evaluated the impact of CH on the POBS of two commonly used sealers (AH Plus and Bio-C) across coronal, middle, and apical sections of the root. The findings provide valuable insights into the adhesive properties of these materials and their clinical implications.

The use of 5 mL of 17% EDTA activated by passive ultrasonics, followed by 5 ml of distilled water, was applied for intracanal medicament removal. This protocol aligns with findings of Stevens et al., who reported improved sealer penetration and reduced leakage in smear-free dentin using a similar method .[21] Despite various protocols, no method has yet achieved complete removal of CH from root canals.

The POBS is widely used to evaluate dentin-sealer shear stress closely simulating clinical conditions .[22,23] It provides consistent, quantifiable results even when bond strength is low .[22-24] In this study, a plungers with flat-ended of 0.5 mm, 0.7 mm, and 1.0 mm diameters were employed to apply compressive force to the apical, middle, and coronal slices, respectively, ensuring optimal contact with each canal region during POBS testing. Factors such as the sealer's adhesion to dentin, plugger diameter, specimen thickness, and orientation can all influence the measured bond strength .[22]

The comparison between sealers showed comparable bonding performance in control group, consistent with findings in previous studies.[25-27]

The study found that CH reduced the bond strength of both sealers, with a more pronounced effect on Bio-C. AH Plus demonstrated greater resistance to the negative impact of the medicament, which may be attributed to its slightly acidic pH that induces a mild self-etching effect on dentin, thereby enhancing its adhesion to the canal walls.[28] These findings aligns with the results of Ghabraei et al. [29], who reported that residual CH can act as a physical barrier, impeding the formation of chemical bonds between the sealer and dentin. This interference hinders proper adaptation of the sealer to the dentin surfaces, ultimately leading to a reduction in POBS. However, this contrasts with other studies [30,31] which reported that CH enhanced the dislocation resistance of calcium silicate-based sealers. This improvement was attributed to residual CH promoting chemical bonding by facilitating hydroxyapatite formation at the sealer–dentin interface.

Bioceramic sealers are hydrophilic in nature and exhibit a low contact angle, which enables them to spread effectively over dentinal surfaces, promoting better adaptation and penetration into root canal irregularities.[32] However, this favorable property may be compromised when CH is used as an intracanal medicament. Yassen et al. [33] examined the impact of various regenerative endodontic protocols, including the application of CH, on the physicochemical properties of dentin. Their findings revealed that CH treated dentin demonstrated significantly reduced wettability due to decreased surface energy. This alteration may hinder the sealer's ability to adequately spread and infiltrate dentinal tubules, thereby impairing mechanical retention and ultimately leading to a reduction in bond strength. Additionally, the highly alkaline nature of CH can adversely alter the structural integrity of root canal dentine, potentially compromising the bonding ability of endodontic sealers. [34-36]

In this study, the apical third showed the POBS, followed by the middle and coronal thirds. This is consistent with Ali et al. [37], who reported similar results. The coronal and middle portions often exhibit an oval or flattened cross-section. Such anatomical variations can result in poor adaptation of the main GP cone, which may have contributed to the reduced bond strength observed. The greater resistance in the apical third may be due to its circular cross-section, which likely enhances mechanical retention. Similar results have also been reported in other studies .[38,39]

CONCLUSION

Using CH as an intracanal medicament adversely affected the bond strength to dentin, with a more pronounced impact on Bio-c sealer.

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