Research Article

Influence of Intracanal Endodontic Medicaments on the Push-Out bond Strength of Bioceramic Types of Cement: An *ex vivo* Study

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ABSTRACT

The study evaluated the impact of Intracanal Medicaments (IMs) on the Push-out Bond Strength (PBS) of MTA and TotalFill Bioceramic (BC) Root Repair Material (RRM). The study randomly divided 88 human single-canaled premolars into four subcategories each in TotalFill BC RRM and Mineral Trioxide Aggregate (MTA) groups. Cement was compressed until bond failure occurred to evaluate PBS in a universal testing machine. The failure mode was assessed. Analyses included Chi-square, one-way ANOVA and Tukey's *post hoc* tests at a 5% significance level. The PBS was substantially stronger with Totalfill BC RRM compared to MTA, regardless of IM employed. After placing calcium hydroxide IM, Totalfill BC RRM had the strongest PBS (87.21±64.49 MPa). There were statistically highly significant variations between the PBS of IM across the two bioceramic cements ($p<0.01$). Similarly, statistically significant variances were documented between the PBS of control groups ($p<0.05$) and modified Triple Antibiotic Paste (mTAP) groups between the two bioceramic cements ($p<0.01$). The overall material failure difference rates of the evaluated types of cement were statistically significant ($p<0.01$). MTA caused 36.4% adhesive and 40.9% of mixed failure modes, while Total fill BC RRM caused 65.9% cohesive failures. There were significant variances in the failure mode of calcium hydroxide IM between the two bioceramic cements ($p=0.03$). BC RRM strengthened the bond better than MTA regardless of IM. Further, BC RRM could replace MTA after IM disinfects the root canal in regenerative endodontic treatment methods or apexification.

Keywords: Calcium hydroxide, Calcium silicate cement, Intracanal medicaments, Regenerative endodontic procedures, Triple antibiotic paste.

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INTRODUCTION

Regenerative Endodontic Procedures (REPs) typically begin with root canal disinfection, subsequently proceeding with the incorporation of a blood clot and/or stem cell precursors into the Root Canal (RC) and later sealed with a microbe-resistant restoration to enable healing of the tissues along with root maturation.[1] Marginal adaptation and the bonding resilience of endodontic material to root dentin are critical variables in preventing apical or coronal leakage.[2] Intracanal Medicaments (IM) should be eliminated from the RC to preserve the sealing and bonding effectiveness of the permanent root-filling materials.[3] With a growing

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interest in REP, effective IM removal turns out even more difficult as the debridement techniques are not utilized to protect the delicate dentinal walls. As a result, there is a dearth of knowledge regarding their possible impact on the bonding property of calcium silicate cement employed in REP.[4]

Chemo-mechanical approaches, such as employing calcium hydroxide, are necessary to eliminate bacteria in RC systems. In recent years, calcium silicate-based IMs have been developed.[5] Bio-C Temp is a readily available calcium silicate paste utilized as an IM. Its limited dissolution compared to calcium hydroxide permits an extended diffusion of hydroxyl ions, raising the pH and inhibiting microbial growth.[6] The material has been shown to exhibit a bioactive potential to promote osteoblast cell survival and development, hence, enhancing periapical repair.[7] Nevertheless, there is limited evidence on how it affects the capacity of calcium silicate cement to bind to RC dentin and bonding durability.[6] One of the most commonly used IM in REP is Triple Antibiotic Paste (TAP), which constitutes metronidazole, ciprofloxacin and minocycline. The primary disadvantage of TAP is tooth discolouration due to minocycline.[5] Another choice of IM frequently used in clinical practice is a modified TAP (mTAP) in which minocycline is replaced with amoxicillin.[1] Despite its regenerating properties, TAP is acidic and might cause inadequate bonding to dentin if not eliminated completely from the root canal.[2]

Mineral Trioxide Aggregate (MTA) excelled at sealing and repairing hard tissues. MTA is commonly used as root-end filler owing to its biocompatible, osteogenic and regenerative properties. Aside from these benefits, MTA has significant limitations, including weak handling characteristics, prolonged setting time and discolouration potential.[8] TotalFill Bioceramic (BC) Root Repair Material (RRM) is an advanced calcium silicate cement, designed to address the shortcomings of MTA. It is a water-based, premixed bioactive cement that takes less time to set than MTA and with compressive strength comparable to MTA.[9-12] In addition, it does not cause tooth discolouration.[5] Following canal disinfection and medication, the IM should be taken out of the RC before the filling material is applied. One of the standards for calcium silicate types of cement is that they are resistant to dislodgement when subjected to occlusal or surgical operations.[13] This study evaluated the impact of IMs on the Push-out Bond Strength (PBS) of TotalFill BC RRM and MTA.

MATERIALS AND METHODS

Randomly selected sound human premolars removed for periodontal or orthodontic purposes were obtained with consent from the patient. Only teeth with single RC, minimal apical curvature of less than 5°, without calcification, resorption (internal/external), prior endodontic therapy, cavities, or fractures were included. Overly small teeth roots of less than 20 mm were excluded. Using ultrasonic scalers and distilled water, calculus and soft tissue were removed from the exterior surfaces of the root. The study used G*Power 3.1.9.7 (Heinrich-Heine-Universität, Düsseldorf, Germany) to calculate a sample of 88 teeth, randomly assigning them to MTA and Totalfill BC RRM groups and allocating them to four IM subcategories (*n*=11/category).

Teeth preparation

Most PBS studies[6,14] prepared and evaluated teeth specimens as follows: Sectioning crowns below the cementoenamel junction made all roots 16 mm long. RCs were formed using ProTaper Universal rotating files up to F5. Five milliliters of 2.5% sodium hypochlorite were irrigated between file sizes with a 27-gauge needle. Pesso reamers 1-5 were used to build a 1.25-mm-diameter, 10-mm-long parallel canal. Irrigating the RC with 5 mL of 17% Ethylenediaminetetraacetic Acid (EDTA) removed the smear layer. To prevent earlier irrigants from lasting longer, 10 mL of saline irrigation was used. The RCs were dried using sterile paper tips.

Teeth were divided into four groups at random: control group (without IM), experimental groups were calcium hydroxide paste (UltraCalTM XS, Ultradent, Germany), Bio-C Temp (Angelus Indústria de Produtos Odontológicos, Brazil) and mTAP paste (equal parts of metronidazole, ciprofloxacin and amoxicillin in sterile distilled water). The IMs were injected using its syringe carrier. To fill the RC, the applicator end was placed 3 mm shorter than its working length and gently removed. Each tooth received mesiodistal and buccolingual radiographs to verify RC obturation. Simulating *In vivo* conditions, the access cavity was restored with temporary restoration and specimens were incubated at 37°C and 100% humid environment for 3 weeks.

Following three weeks, the RCs were carefully irrigated with 2.5% sodium hypochlorite (5 mL), 17% EDTA (10 mL) and saline (10 mL) to eliminate the IMs. With sterile paper tips, all RCs were dried. Each step of preparing a tooth specimen was done by an expertized single operator. Teeth were inserted into a 12 mm *silico*n mold. The middle-third of the root was sectioned into two 2±0.05 mm parallel transverse slices (*n*=88) in the coronal-to-apical plane with a low-speed Buehler Isomet saw under constant water irrigation. Samples from each group were assigned at random into two distinct categories (*n*=44) by calcium silicate cement type which included MTA (Angelus Indústria de Produtos Odontológicos, Brazil) and Totalfill RRM (FKG, Dentaire, Brasseler, USA), supplied in a readily available syringe. The cement was placed by the expert in the slice lumens and condensed on a glass plate with an endodontic plugger (5/7, HuFriedyGroup, Illinois). The samples were kept in gauze that was immersed in sterile water and incubated at 37°C for one week.[6]

Push-out bond strength testing

Universal testing equipment (Instron testing machine, Model 5967; USA) was used to measure PBS in calcium silicate cement. The bond ruptured when compressed and the maximum displacement force was recorded. A digital microscope (KH-7700, Hirox Co., Tokyo) was used to evaluate failure modes, identifying adhesive, cohesive and mixed failures. The failure mode was determined using a blinded observer. PBS was estimated using the formula:

$$\text{Bond strength (MPa)} = \frac{\text{Force for displacement (N)}}{\text{bonded surface area (mm}^2\text{)}}.$$

$$\text{Bonded surface area} = 3.14 \times \text{radius of RC} \times \text{slice thickness}.$$

Statistical analysis

The data was evaluated with SPSS 26.0 (SPSS Inc., Chicago, IL, USA). After testing for normality by applying the Shapiro-Wilk test, a one-way ANOVA and Tukey's *post hoc* multiple comparison tests were carried out. PBS of the two bioceramic cements was contrasted using an unpaired *t*-test. The Chi-square test was employed to assess if IM affected the failure type at a 5% significance level.

RESULTS

The PBS was substantially stronger with Totalfill BC RRM compared to MTA, regardless of IM employed. Table 1 shows the mean PBS of MTA and Totalfill BC RRM by subcategories. After placing calcium hydroxide intracanally, Totalfill BC RRM had the strongest PBS (87.21±64.49 MPa). There were statistically highly significant variations between the PBS of IM across the two bioceramic cements ($p<0.01$). Similarly, statistically significant variances were documented between the PBS of control groups ($p<0.05$) and mTAP groups between the two bioceramic cements ($p<0.01$).

In the BC RRM group, the PBS did not differ significantly between the control group and calcium hydroxide ($p=0.30$), control and mTAP groups ($p=0.14$) and calcium hydroxide and mTAP groups ($p=0.97$). On the contrary, statistically highly significant differences were noticed between Bio-C Temp and mTAP groups, Bio-C Temp and calcium hydroxide and Bio-C Temp and control groups ($p<0.01$). Similarly, within the MTA group, statistically significant changes were noted between the control specimens and Bio-C Temp and mTAP and Bio-C Temp groups ($p<0.05$). However, Bio-C Temp exhibited considerably lower bond strength than the other IM and the control groups.

The type of failure modes was statistically insignificant related to IM across the BC RRM ($p=0.68$) and MTA cements ($p=0.19$). The overall material failure difference rates of the evaluated types of cement were statistically significant ($p<0.01$). MTA caused 36.4% adhesive and 40.9% of mixed failure modes, while Totalfill BC RRM caused 65.9% cohesive failures (Table 2). There were statistically significant variations in the failure mode of calcium hydroxide IM between the two bioceramic cements ($p=0.03$).

DISCUSSION

IMs can be employed in trauma-related multiple-visit endodontics and REPs.[15] Totalfill BC RRM may replace MTA in REPs or apexification techniques due to its simple nature of handling and lack of tooth structure colour alteration. These medications can be used for a week to an extended period.[16] However, the American Association of Endodontists advises IM for a week after clinical regeneration operations.[17] Calcium hydroxide therapy for seven days between appointments led to a negative culture of intraarticular microbes.[18] Nonetheless, long-term exposure to interappointment

Table 1: Comparison of mean PBS (MPa) of MTA and Totalfill BC RRM in various subcategories.

Cement	IMs				ANOVA	Tukey's *post hoc* test					
	Control (1)	$Ca(OH)_2$ (2)	Bio-C Temp (3)	mTAP (4)	*p*-value+	1 Vs 2	1 Vs 3	1 Vs 4	2 Vs 3	2 Vs 4	3 Vs 4
Totalfill BC fast set putty	63.07±39.22	87.21±64.49	6.24±5.72	86.48±31.53	0.000**	0.3	0.00	0.14	0.00	0.97	0.00
MTA	29.15±35.2	36.76±60.28	5.97±4.51	34.29±21.07	0.2	0.72	0.04	0.68	0.11	0.90	0.00
p-value++	0.04	0.07	0.90	0.0001							

+ANOVA; ++*t*-test; $p\leq 0.05$-Significant; $p\leq 0.01$-Highly significant; IMs-Intracanal medicaments.

Table 2: Comparison of various modes of failure in each subcategory.

Cement	Intracanal medicaments	Failure types n(%)			*p*-value
		Adhesive	Cohesive	Mixed	
Totalfill BC RRM	Control[a]	2(18.2)	7(63.6)	2(18.2)	0.68
	$Ca(OH)_2$[A]	1(9.1)	8(72.7)	2(18.2)	
	Bio-C Temp[b]	2(18.2)	5(45.5)	4(36.4)	
	mTAP[c]	1(9.1)	9(81.8)	1(9.1)	
Total (*n*=44)[A]		6(13.6)	29(65.9)	9(20.5)	
MTA	Control[a]	3(27.3)	2(18.2)	6(54.5)	0.19
	$Ca(OH)_2$[B]	5(45.5)	2(18.2)	4(36.4)	
	Bio-C Temp[b]	7(63.6)	2(18.2)	2(18.2)	
	mTAP[c]	1(9.1)	4(36.4)	6(54.5)	
Total (*n*=44)[B]		16(36.4)	10(22.7)	18(40.9)	

Similar lowercase letters indicate the presence of insignificant differences in failure modes of the control, Bio-C Temp and mTAP between the two cements (p=0.08, p=0.09, p=0.06 respectively). Different uppercase letters indicate a significant difference in the failure mode of Ca(OH) between the Totalfill BC RRM and MTA (p=0.03) and overall failure modes between the two bioceramic cements (p<0.01).

medication may degrade root dentin by collagen degeneration in calcium hydroxide IM or exorbitant demineralization in antibiotic paste, which could influence root fracture resistance.[19] Nevertheless, there is a scarcity of literature describing the approach for the complete removal of IMs from the RC system.[20,21] Thus, this study compared calcium hydroxide and mTAP to MTA on Totalfill BC RRM after short-term treatment. Gokturk *et al.*[22] observed that calcium hydroxide or ciprofloxacin-metronidazole antibiotic paste did not affect BC sealer dislodgement resistance.

Previous studies used the PBS method to investigate calcium silicate cement-dentin bond strength.[4,16] This practical and reliable method was used in this study.[13] After PBS testing, specimens were inspected for failure type. Most MTA subtype failures were cohesive or mixed, confirming previous data.[16,23] Due to smaller and more uniform BC RRM particles, dentinal tubule penetration and adhesion improved, explaining this failure mechanism. This contradicts Kadic *et al.*[24] observed mixed bond failures in bioceramic cement. The contradictory outcomes may be due to different study designs. This study used middle root slices, while Kadic *et al.*[24] used apical root slices. Additionally, the sections in this investigation were created following material insertion in the RC, which may affect material adaptability.[25] Berkhoff *et al.*[3] determined that more than 80% of TAP remained in the RC. Another study indicated that mTAP promotes dentin-calcium and phosphorus balance.[26] Topcuoglu *et al.*[23] documented no impact of calcium hydroxide and mTAP on MTA dislodgement resistance, probably due to experimental methods. Topcuoglu *et al.*[23] utilized sodium hypochlorite and sterile water to eliminate IM, whereas our work used sodium hypochlorite, EDTA and saline. A chelating agent after IM may change dentin surface chemical properties, compromising material adhesion.[27]

In this study, MTA and Totalfill BC RRM had the strongest PBS in the calcium hydroxide IM group. It was statistically insignificant compared to control groups without IM. This complements recent findings that calcium hydroxide did not impair fast-setting, pre-mixed calcium silicate cement bond strength.[5,28] Other investigations have demonstrated that pretreatment calcium hydroxide application increases calcium silicate cement's PBS,[4,29] possibly owing to the cements' reactivity with remnants, which increased marginal adaptability. Calcium hydroxide impairs MTA bonding and adaptation.[5] Calcium hydroxide is an indispensable IM for its antibacterial properties and capacity to build hard tissue by breaking down into Ca^{2+} and OH^- ions, offering numerous benefits. Calcium hydroxide pastes for immediate use contain breakdown inhibitors to prolong release.[30] Bio-C Temp increases Ca_2^+ and dentin microhardness.[31,32] It exhibited the lowest bonding strength in our study, possibly due to Bio-C Temp residues. Insufficient data exist on the elimination of Bio-C Temp from the RC and current approaches cannot entirely eliminate IM.[21,33] Polymer chains in Bio-C Temp prevent hydrated calcium silicate hardening. The residues of this IM could react with calcium silicate-based types of cement and prevent them from chemically bonding with dentin, lowering cement's dentin adaptability and PBS.[34]

Bio-C Temp causes teeth discolouration[35] and damages dental pulp.[31] In this trial, MTA caused adhesive or mixed failures regardless of IM. Due to MTA's large particle size, it cannot penetrate the dentinal tubule, resulting in higher internal cohesion than dental adhesion.[8] BC RRM, especially after Bio-C Temp, produced cohesive failures. This study confirms current investigations on TotalFill RRM, which is identical to Bio-C Repair.[5,6,24] Earlier MTA failure investigations have documented varied outcomes. Saghiri *et al*.,[36] and Dawood *et al*.[37] documented adhesive failures, whereas others reported mixed failures.[5,38] These differences may be caused by storage conditions, size and number of dentinal tubule slices and procedures like sectioning of roots after cementing.

The present study was restricted by its incapacity to simulate real-world circumstances, such as blood contamination. To evaluate practical implications, long-term clinical studies are warranted. Further in this study, micro-CT evaluation of gap formation had not been utilized before evaluating the PBS assessment. This deference may have disguised material adaptation's effect on study results. After root sectioning, BC cement IM may not exactly mimic clinical settings and may have skewed the findings.[39]

CONCLUSION

Considering these limitations, BC RRM appears to bond better than MTA, making it an appropriate apical plug for exposed apices. Further research is needed to analyze the lower bond strength of Bio-C Temp. furthermore, additional investigations are warranted to determine how irrigation materials and cement application methods and strategies influence BC cement PBS.

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CONFLICT OF INTEREST

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ABBREVIATIONS

BC: Bioceramic; **EDTA:** Ethylenediaminetetraacetic acid; **IM:** Intracanal medicament; **MTA:** Mineral trioxide aggregate; **mTAP:** modified triple antibiotic paste; **PBS:** Push-out bond strength; **RC:** Root canal; **REP:** Regenerative endodontic procedures; **RRM:** Root repair material; **TAP:** Triple antibiotic paste.

SUMMARY

The PBS of calcium silicate-based types of cement declined with Bio-C Temp, whereas calcium hydroxide IM exhibited a higher PBS. BC RRM strengthened bonds better than MTA regardless of IM. Further, BC RRM could replace MTA after IM disinfects the RC in REPs or apexification.

REFERENCES

1. Oktay EA, Ersahan S, Gokyay S. Effect of intracanal medicaments used in endodontic regeneration on the push-out bond strength of a calciumphosphate-silicate-based cement to dentin. Pak J Med Sci. 2018;34:310-5.
2. Dumani A, Yilmaz S, Yoldas O, Bek Z. Effect of irrigation technique for removal of triple antibiotic paste on bond strength of MTA to root dentin. Braz Oral Res. 2016;30:e62.
3. Berkhoff JA, Chen PB, Teixeira FB, Diogenes A. Evaluation of triple antibiotic paste removal by different irrigation procedures. J Endod. 2014;40:1172-7.
4. Nagas E, Cehreli Z, Uyanik M, Vallittu P, Lassila L. Effect of several intracanal medicaments on the push-out bond strength of ProRoot MTA and Biodentine. Int Endod J. 2016;49:184-8.
5. Alsubait S, Alsaad N, Alahmari S, Alfaraj F, Alfawaz H, Alqedairi A. The effect of intracanal medicaments used in Endodontics on the dislocation resistance of two calcium silicate-based filling materials. BMC Oral Health. 2020;20:57.
6. Almohareb RA, Barakat RM, Algahtani FN. Effect of bioceramic intracanal medication on the dentinal bond strength of bioceramic cements: an *ex vivo* study. Peer J. 2024;12:e17826.
7. Lopes C, Delfino M, Tanomaru-Filho M, Sasso-Cerri E, Guerreiro-Tanomaru JM, Cerri P. Bioactive potential of Bio-C Temp demonstrated by systemic mineralization markers and immunoexpression of bone proteins in the rat connective tissue. J Mater Sci Mater Med. 2024;35:13.
8. Aly Y, El Shershaby S, El-Sherif S. Bond strength and marginal adaptation of a novel root-end filling material. Bull Natl Res Cent. 2020;44:142.
9. Zhang W, Peng B. Tissue reactions after subcutaneous and intraosseous implantation of iRoot SP, MTA and AH Plus. Dent Mater J. 2015;34:774-80.
10. Guo YJ, Du TF, Li HB, Shen Y, Mobuchon C, Hieawy A, *et al*. Physical properties and hydration behavior of a fast-setting bioceramic endodontic material. BMC Oral Health. 2016;16:23.
11. Walsh RM, Woodmansey KF, Glickman G, He J. Evaluation of Compressive Strength of Hydraulic Silicate-based Root-end Filling Materials. J Endod. 2014;40:969-72.
12. Shokouhinejad N, Nekoofar MH, Razmi H, Sajadi S, Davies TE, Saghiri M, *et al*. Bioactivity of EndoSequence Root Repair Material and Bioaggregate. Int Endod J. 2012;45:1127-34.
13. Shahi S, Rahimi S, Yavari HR, Samiei M, Janani M, Bahari M, *et al*. Effects of various mixing techniques on push-out bond strengths of white mineral trioxide aggregate. J Endod. 2012;38:501-4.
14. Brichko J, Burrow MF, Parashos P. Design Variability of the Push-out Bond Test in Endodontic Research: A Systematic Review. J Endod. 2018;44:1237-45.

15. Athanassiadis B, Abbott P V, Walsh LJ. The use of calcium hydroxide, antibiotics and biocides as antimicrobial medicaments in endodontics. Aust Dent J. 2007;52:S64-82.
16. Alsubait SA, Hashem Q, AlHargan N, AlMohimeed K, Alkahtani A. Comparative evaluation of push-out bond strength of ProRoot MTA, bioaggregate and biodentine. J Contemp Dent Pract. 2014;15:336-40.
17. American Association of Endodontists (2018) clinical considerations for a regenerative procedure. https://f3f142zs0k2w1kg84k5p9i1o-wpengine. netdna-ssl.com/specialty/wp-content/uploads/sites/2/2018/06/ConsiderationsForRegEndo_AsOfApril2018.pdf. 2018;
18. Sjogren U, Figdor D, Spangberg L, Sundqvist G. The antimicrobial effect of calcium hydroxide as a short-term intracanal dressing. Int Endod J. 1991;24:119-25.
19. Yassen GH, Chu TM, Eckert G, Platt JA. Effect of Medicaments Used in Endodontic Regeneration Technique on the Chemical Structure of Human Immature Radicular Dentin: An *In Vitro* Study. J Endod. 2013;39:269-73.
20. Chou K, George R, Walsh LJ. Effectiveness of different intracanal irrigation techniques in removing intracanal paste medicaments. Aust Endod J. 2014;40:21-5.
21. Wigler R, Dvir R, Weisman A, Matalon S, Kfir A. Efficacy of XP-endo finisher files in the removal of calcium hydroxide paste from artificial standardized grooves in the apical third of oval root canals. Int Endod J. 2017;50:700-5.
22. Gokturk H, Bayram E, Bayram HM, Aslan T. Effect of double antibiotic and calcium hydroxide pastes on dislodgement resistance of an epoxy resin-based and two calcium silicate-based root canal sealers. Clin Oral Investig. 2017;21:1277-82.
23. Topcuoglu H, Arslan H, Akcay M, Saygili G, Cakici F, Topcuoglu G. The Effect of Medicaments Used in Endodontic Regeneration Technique on the Dislocation Resistance of Mineral Trioxide Aggregate to Root Canal Dentin. J Endod. 2014;40:2041-4.
24. Kadic S, Baraba A, Mileti I, Ionescu A, Brambilla E, Malcic A, *et al*. Push-out bond strength of three different calcium silicate-based root-end filling materials after ultrasonic retrograde cavity preparation. Clin Oral Inves. 2018;22:1559-65.
25. Lo Giudice G, Cutroneo G, Centofanti A, Artemisia A, Bramanti E, Militi A, *et al*. Dentin Morphology of Root Canal Surface: A Quantitative Evaluation Based on a Scanning Electronic Microscopy Study. Biomed Res Int. 2015;2015:164065.
26. Simsek H, Coruh M, Cakici F, Kucukekenci FF, Gurbuz T, Cakici EB. Investigation of mineral content of root canal dentin after the application of various antibiotic pastes using energy-dispersive X-ray detector. Microsc Res Tech. 2019;82:144-8.
27. Yassen GH, Sabrah AHA, Eckert GJ, Platt JA. Effect of Different Endodontic Regeneration Protocols on Wettability, Roughness and Chemical Composition of Surface Dentin. J Endod. 2015;41:956-60.
28. Gokturk H, Ozkocak I. The effect of different chelators on the dislodgement resistance of MTA Repair HP, MTA Angelus and MTA Flow. Odontology. 2021;110:20-6.
29. Al-haddad AY, Kacharaju KR, Haw LY, Yee TC, Rajantheran K, Mun CS, *et al*. Effect of Intracanal Medicaments on the Bond Strength of Bioceramic Root Filling Materials to Oval Canals. J Contemp Dent Pr. 2020;21:1218-21.
30. Fava LRG, Saunders WP. Calcium hydroxide pastes: classification and clinical indications. Int Endod J. 1999;32:257-82.
31. Olivieira L, DeSouza G, DaSilva G, Magalhães T, Barbosa G, Moura C. Biological parameters, discolouration and radiopacity of calcium silicate-based materials in a simulated model of partial pulpotomy. Int Endod J. 2021;54:2133-44.
32. Alshamrani A, AlDeeb L, Almohareb T, Alahdal K, Maawadh A, Alrahlah A. Effect of canal medicaments triple antibiotic paste, Bio-C Temp and Nano-silver gel activated by visible blue light on canal dentin microhardness and extrusion bond strength of AH plus sealer: A SEM and EDX analysis. Photodiagnosis Photodyn Ther. 2024;47:104088.
33. Zhou J, Liu T, Guo L. Effectiveness of XP-Endo Finisher and passive ultrasonic irrigation on intracanal medicament removal from root canals: a systematic review and meta-analysis. BMC Oral Health. 2021;21:294.
34. Villa N, Santos V, DaCosta U, Mendes AT, Duarte P, DaRosa R, *et al*. A New Calcium Silicate-Based Root Canal Dressing: Physical and Chemical Properties, Cytotoxicity and Dentinal Tubule Penetration. Braz Dent J. 2020;31:598-604.
35. de Campos IVB, Vieira WA, de Almeida RF, Gabriel PH, Marciano MA, Gomes BPFA, *et al*. *In vitro* dental discoloration provoked by intracanal calcium silicate-based dressing used for regenerative endodontic procedures: a one-year spectrometric an. J Endod. 2023;49:846-51.
36. Saghiri MA, Garcia-godoy F, Gutmann JL, Sheibani N, Asatourian A, Lotfi M, *et al*. Removal of White Mineral Trioxide Aggregate Cement : A Promising Approach. Biomed Res Int. 2013;2013:469164.
37. Dawood AE, Manton DJ, Parashos P, Wong RHK, Palamara JEA, Reynolds EC. Push-out bond strength of CPP-ACP-modified calcium silicate-based cements. Dent Mater J. 2015;34:490-4.
38. Stefaneli Marques JH, Siva-Sousa Y, Rached-Junior F, DeMacedo L, Mazzi-Chaves J, Camilleri J, *et al*. Push-out bond strength of different tricalcium silicate-based filling materials to root dentin. Braz Oral Res. 2018;32:e18.
39. Brito-Junior M, Leoni GB, Pereira R, Faria-e-silva A, Gomes E, Silva-Sousa Y, *et al*. A Novel Dentin Push-out Bond Strength Model That Uses Micro-Computed Tomography. J Endod. 2015;41:2058-63.

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