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Enhancing Bond Strength of Silicate-Based Cements with Intracanal Medicaments: A Literature Review

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Abstract

Objectives Ensuring strong adhesion of silicate-based cement to dentin during root canal therapy is crucial for achieving optimal results. This review aims to evaluate how different intracanal medicaments impact the tensile bond strength of silicate-based cement in root canal treatments.

Methods A thorough electronic search was performed using the PubMed and Google Scholar databases for articles published from 2000 to 2023.

Results The studies included in this review evaluated the effects of various intracanal medicaments, including calcium hydroxide, chlorhexidine, triple antibiotic paste, double antibiotic paste, simvastatin, and bioactive glass, on the bond strength of silicate-based cements like mineral trioxide aggregate (MTA), Biodentine, and calcium-enriched mixture (CEM) cement. The results demonstrated varied impacts of these medicaments; some improved bond strength, while others had minimal effect. Specifically, calcium hydroxide frequently enhanced bond strength, and some antibiotic pastes showed similar benefits. In contrast, medicaments such as phenolic preparations and formaldehyde were found to have limited efficacy and potential toxicity.

Conclusion The type, concentration, and application site of intracanal medicaments significantly impact bond strength. This review highlighted the potential advantages of these medicaments, including improved root canal disinfection and enhanced push-out bond strength of commonly used dental cements. These insights can help dental professionals optimize root canal treatments and improve patient outcomes.

Keywords Dental cements; Bond strength; Silicate cement; Root canal medicament

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Introduction

The primary objective of root canal treatments is to eliminate bacteria and other factors that cause pain, abscesses, and bone infections. An effective dental cement should be biocompatible, nontoxic, insoluble in tissue fluids, radiopaque, and capable of preventing leakage.[1]

In recent decades, silicate-based cements like mineral trioxide aggregate (MTA), Biodentine, and calcium-enriched mixture (CEM) cement have gained prominence in root canal treatments for their distinct merits and drawbacks. MTA, a powder widely used in endodontic procedures, serves purposes such as pulp capping, filling root canal ends, and repairing perforations.

CEM cement shares similar clinical applications with MTA, despite differences in its chemical and physical properties.[2] Biodentine, another silicate-based cement, sets more rapidly compared to other similar substances mentioned earlier. It serves as an alternative for retrograde filling materials and is recognized for its biocompatibility, as well as its capability to promote odontoblast differentiation.[3, 4]

In endodontics, intracanal medicaments are primarily used for disinfecting the root canal system.[5] The application of intracanal medicaments may potentially influence the chemical and physical properties of silicate-based cement.[6,7,8] Among the notable and widely recognized intracanal medicaments are calcium hydroxide, chlorhexidine, triple antibiotic paste (TAP), and double antibiotic paste (DAP). This review examined how intracanal medicaments affect the tensile bond strength of silicate-based cement.

Materials

A comprehensive electronic search was conducted using PubMed and Google Scholar to investigate how intracanal medicaments affect the tensile strength of silicate-based cement. Relevant MeSH keywords, including dental cement, bond strength, silicate cement, and root canal medicament, were employed to identify relevant studies published between 2000 and 2023. Additionally, a manual search was conducted to augment the findings. Only studies specifically examining the impact of intracanal medicaments on the bond strength of silicate-based cement, with a focus on push-out tests, were included. Articles with inadequate results or methodological flaws were excluded, while studies conducted under both clinical and laboratory conditions were considered for analysis.

Intracanal medicaments:

1-Calcium Hydroxide

Calcium hydroxide (Ca(OH)2) or CH was first introduced in 1920 and continues to be the predominant intracanal medicament in use today.[9] This substance is employed to facilitate dentinal bridging, eradicate bacteria from root canals, and perform apexification in necrotic teeth. Calcium hydroxide is recognized for its antibacterial efficacy, tissue dissolution capability, inhibition of root resorption, and promotion of hard tissue formation.[10] The antimicrobial mechanism decomposes this material into calcium ions and hydroxyl. It makes an essential environment in which enzyme-related activities for metabolism, growth, and cell division of bacteria are disturbed. However, calcium hydroxide is potentially toxic and can lead to complications such as soft tissue damage, chronic inflammation, and cell necrosis.[11] Also, it has been reported that it is inefficient in clinically destroying microorganisms such as Enterococcus faecalis and Candida albicans.[9] The reason for this inefficiency is the inability of calcium hydroxide to reach the targeted area and the buffering capacity of blood and tissue fluids.[12,13]

2-Chlorhexidine

Chlorhexidine (CHX) is another widely recognized intracanal medicament, extensively studied for its beneficial properties. Several in vitro [14] and in vivo [15] studies have demonstrated the antibacterial effects of chlorhexidine. CHX has antimicrobial effects against Gram-positive and Gram-negative bacteria, yeasts, and fungi, particularly Candida albicans.[16] This antibacterial effect depends on the concentration of the substances and the preparation (liquid, gel, controlled-release device).[17] CHX gel form can be straightforward and user-friendly because it is delivered into and removed from the canal with a syringe.

3-Chlorhexidine mixed with calcium hydroxide

In recent years, the combination of Ca(OH)2 and CHX has been studied due to their antimicrobial properties and the hypothesis that they may synergistically enhance efficacy.[18] Some recent studies have demonstrated that chlorhexidine mixed with calcium hydroxide has significant antimicrobial ability and enhances the healing of periapical tissues; however, its sufficiency is still unclear.[19,20,21]

4-Phenolic preparations

Phenolic preparations have historically been popular as intracanal medicaments. It is now recognized that these substances can cause toxicity, although their use as a camphorated solution has been explored to reduce this risk. [22] Phenols did not have demonstrated promising antibacterial properties in trials.[23]

5-Halogens

Iodine-potassium iodide (IKI) serves as an antibacterial agent. In vitro experiments have shown that incorporating IKI into Calcium hydroxide enhances its antibacterial effectiveness.[24] Chlorinated mixtures are used to irrigate root canals.[22]

6-Formaldehyde

Formaldehyde is a volatile substance that releases antimicrobial vapor.[25,26] However, the substance is known to be toxic, carcinogenic, and mutagenic [27], and several better alternatives exist.[25,26]

7-Steroids

Steroids are utilized to alleviate pain and inflammation within the root canal. Ledermix is a specific brand that combines the anti-inflammatory corticoid triamcinolone acetonide with demeclocycline, an antibiotic.[28] The only rationale for adding antibiotics to Ledermix is to minimize the risk of possible corticoid-induced reduction in the host immune response.[29] With therapeutic effects, Ledermix can spread through dentinal tubules and cementum to reach the periodontal and periapical tissues.[30] This product's noted property is pain relief essential to acute pulp and periodontium inflammatory conditions.[31] Ledemix can be used for pulp capping and pericementisis, and it is also used when other anti-inflammatory drugs fail.[32, 33]

8-Triple antibiotic paste (TAP)

Hoshino and colleagues introduced triple antibiotic paste (TAP) in 1996 to address the broad spectrum of complications from root canal infections. Single antibiotic treatments are inadequate due to the diverse nature of these complications. Additionally, combining antibiotics helps mitigate the risk of developing antibiotic resistance.[34]

TAP contains metronidazole, ciprofloxacin, and minocycline powders in a ratio of 1:1:1, mixed with saline. Each component has its specific property. For example**,** as most dental infections are caused by anaerobic bacteria, metronidazole was necessary for the paste.

TAP is an excellent intracanal medicament that can effectively disinfect the canal and has a broad spectrum.[35] Efficiency of TAP in disinfection of immature teeth with apical periodontitis was also reported.[8] Also, TAP promotes pulp-dentin complex development and significantly enhances root wall thickness.[36] It is also biocompatible and doesn't have much toxicity.[37] Despite its excellent properties, tooth discoloration is a significant limitation of TAP usage because of its minocycline content.[38]

9-Double antibiotic paste (DAP)

As mentioned, minocycline can cause darkening in permanent teeth.[39] Therefore, a double antibiotic paste containing metronidazole and ciprofloxacin was introduced.[40] Research shows that DAP has the same disinfecting activity as TAP.[41] DAP can be a good choice in Calcium hydroxide-resistant endodontic infections as an intracanal medicament.[42] It can be concluded that DAP can be used as an alternative to TAP's excellent properties but without the discoloration issue.

10-Simvastatin

Simvastatin belongs to a class of drugs known as statins, primarily used in medicine for their lipid-lowering effects. In addition to reducing fat levels, statins such as simvastatin also

possess beneficial properties, including anti-inflammatory effects and the ability to promote osteoblast differentiation.[43,44] Simvastatin can be used in dentistry due to its effects on bone regeneration and tissue mineralization.[45] Simvastatin is known for its antimicrobial properties and ability to serve as a topical antibacterial agent, showing significant efficacy against oral and periodontal bacteria in various studies.[46]

11-Bioactive Glass

Bioactive glasses were invented in 1969 by Larry L. Hench.[47] Instead of Ca(OH)2, bioactive glasses can be utilized to promote dentin remineralization and bone regeneration. These materials also possess antimicrobial properties that are bolstered when combined with dentin. Under certain conditions, they release calcium, sodium, and silica. Among the various types, Niobium phosphate bioactive glass (NbG) and 45S5 are among the most commonly employed forms.[48]

Silicate-based cement:

1-Portland cement (PC)

The chemical properties of Portland cement and MTA are almost similar. The main difference is the presence of bismuth oxide in MTA as a radio pacifier.[49] Despite the lower cost of PCs, [1] some investigations show limitations in their use as a replacement for MTA, such as their high solubility and lower compressive strength.[50] Overall, PC cannot be used as a substitute for MTA, and more investigation is needed.

2-MTA

MTA, marketed under the brand name Pro-Root, is a powdered substance widely utilized in dentistry, particularly in endodontic procedures. Developed by Tulsa Dental Dentsply in the USA, MTA serves multiple purposes including pulp-capping, filling root canal ends, and repairing perforations.[51]

MTA mainly consists of calcium oxide and silica. To create radiopacity in MTA, Bi2O3 is used in a 1 to 4 ratio.[52] Bismuth oxide in MTA is known as a retarder agent, but it also adversely influences biocompatibility and can cause discoloration.[53] MTA setting time is longer than some other silicate-based materials (2 hours and 45 minutes).[9] Calcium hydroxide is the most essential mixture released from MTA in water. Also, MTA is a bioactive material for bone marrow cells, and because of its pH and Calcium ion release, it stimulates the production of interleukins.[13] MTA is classified within the family of Portland Cement. Upon initial mixing, it forms a colloidal gel crystal that initially has a soft consistency. Within four hours, the gel undergoes hardening.[14] Also, calcium hydroxide production in this process relates to calcium oxide in MTA. [15]

MTA has several types, which are:

Angelus MTA, MTA Fillapex, MTA Plus, Ortho MTA, MTA Bio, MTA Sealer, Fluoride-Doped MTA Cement, Nano-Modified MTA (NMTA), Light-Cured MTA, Endocem MTA (tricalcium silicate, dicalcium silicate and bismuth oxide, calcium hydroxide.[54,50]

3-BioAggregate:

BioAggregate (BA), or DiaRoot, is used for root-end filling, perforation repair, and pulp capping. This compound consists of powder (mixed with H2O) consisting of SiO2 (13.70%), P2 O5 (3.92%), CaO (63.50%), and Ta2 O5 (17%).[55] Also, Calcium hydroxide can be found in BA set form, similar to white ProRoot MTA.[56,57] Studies have shown that BA has an antibacterial activity identical to MTA. They eliminate E. faecalis with some slight differences.[58] After all, BA has proper bioactivity and no reported toxicity. As almost all current information is from laboratory studies, there is a need for appropriate investigations for clinical uses.

4-Biodentine

Biodentine is a recently introduced material used for root canal filling. It features a calcium-silicate base that sets rapidly, typically within approximately 12 minutes after mixing. This product contains tricalcium silicate (80.1%) and calcium carbonate (14.9%) as fillers, along with zirconium oxide for radiopacity. The liquid component includes water, calcium chloride as a setting accelerator, and a water-reducing agent in the form of a hydrosoluble polymer.[59, 60] By incorporating an accelerator and softener, the handling and manipulation of this material become more manageable, and Biodentine achieves its maximum physical properties within one week of setting.

Hence, Biodentine can be used as a replacement for retrograde filling materials.[9] It is considered to reduce microleakage at the tooth-restoration interfaces [61] and also can adhere to dentin without prior etching.[62]

Biodentine can be a proper replacement for dentin because of the components named earlier, and when Biodentine is protected by composite, it can tolerate occlusal forces well.[45, 46] Biodentine, similar to MTA, can be directly placed near the tooth's pulp. It has biocompatibility and can induce odontoblast differentiation and mineralization on pulp cells.[8]

5-Calcium-enriched mixture (CEM)

CEM cement was first introduced in 2006. It contains many components, such as CaO and SiO2.[55] The main difference between the physical properties of CEM cement and MTA is their setting time, film thickness, and flowability.[2] According to Asgary et al.'s investigations, CEM cement's antibacterial activity is even higher than MTA and is similar to Calcium hydroxide.[56] It has the same level of cytotoxicity as MTA [57], and both have a higher biocompatibility in pulp capping.[58] There are successful clinical investigations on CEM cement usage in different endodontic treatments, such as pulpotomy.[63]

6-Endosequence

EndoSequence Root Repair Material (RRM) and EndoSequence Root Repair Putty (RRP) were first introduced by Brasseler USA. EndoSequence is a premixed sealer.[64] This material can enter the dentinal tubules and come in contact with their moisture due to its small particle

size. This property allows EndoSequence to create a mechanical attachment.[65]

According to "Brasseler," EndoSequence is a white injectable material with a high radiopacity.

EndoSequence is used in pulp capping, perforation repair, and many other procedures in endodontics.[50]

Tensile Bond Strength

The assessment of tensile bond strength is typically utilized for evaluating dentin adhesive systems.[66] These tests assess the durability of adhesive bonds, allowing for comparison of the quality of various bonding materials based on their tensile stress at failure.[67] Tensile bond strength tests on the internal root surfaces can be performed using pull-out, push-out, and microtensile methods. The push-out test is favored for its superior reliability and accuracy over the microtensile test, as it has fewer limitations. These tests apply forces parallel to the interface between the bonding agents and dentin.[68,69] All tests in this article were performed by push-out test universal testing machine.

Results

This review encompassed 15 articles identified through the outlined search strategy. While most articles documented beneficial effects of intracanal medicaments on the bond strength of silicate-based cement, some reported no association or even a detrimental impact. A summary of findings is presented in Table 1.

Table 1- Related articles from 2000 to 2023

Author	Title	Tooth type	Tooth no	Groups	Results
Escobar, P.M., et al. (2023) [70]	Influence of bioceramic intracanal medication on the bond strength of bioceramic root canal sealer	freshly-extracted mandibular first molars	20	Group 1: Bio-C Temp (intracanal medication based on bioceramic compounds) + Bio-C Sealer (bioceramic sealer) Group 2: Ultracal XS + Bio-C Sealer	Using bio ceramic intracanal medication alongside bioceramic sealer shows higher bond strength
Foram, P., et al. (2023) [71]	Evaluation of Intracanal Medicaments on Pushout Bond Strength of Calcium Silicate Based	Single-rooted teeth	100	Group 1: 1a: Calcium Hydroxide (1 week) + MTA 1b: Calcium Hydroxide (1 week) + Biodentine Group 2: 2a: TAP (1week) + MTA 2b: TAP (1week) + Biodentine Group 3: 3a: Calcium Hydroxide (3 weeks) + MTA 3b: Calcium Hydroxide (3 weeks) + Biodentine Group 4: 4a: TAP (3 weeks) + MTA 4b: TAP (3 weeks) + Biodentine Group 5: 5a: control (no medicaments) + MTA 5b: control (no medicaments) + Biodentine	-higher bond stengths while using calcium hydroxide -higher bond strength while using intracanal medicament for longer duration (3 weeks > 1 week)
Ghasemi, N., et al. (2022) [72]	Effect of three intracanal medicaments used in pulp regeneration on the push-out bond strength of mineral trioxide aggregate and calcium-enriched mixture: An in vitro study	single root and a single canal human teeth	160	Group 1: 1a: TAP +MTA 1b: TAP +CEM Group 2: 2a: DAP+ MTA 2b: DAP+ CEM Group 3: 3a: simvastatin + MTA 3b: simvastatin + CEM Group 4: 4a: control group (NO intracanal medicament) + MTA 4b: control group (NO intracanal medicament) + CEM	- no significant difference between MTA and CEM bond strength (regardless of the medication) - all medications showed same result as the control group

Table 1- Related articles from 2000 to 2023

Author	Title	Tooth type	Tooth no	Groups	Results
Prado M.C, Martiniano K, et al. (2021) [73]	Do intracanal medications used in regenerative endodontics affect the bond strength of powder-to-liquid and ready-to-use cervical sealing materials?	Central bovine incisors with one circular canal	10	Group 1: 1a : TAP + MTA 1b : TAP + MTA-HP 1c :TAP + ERRM 1d : TAP + BIO-C repair Group 2: 2a : DAP + MTA 2b : DAP + MTA-HP 2c : DAP + ERRM 2d : DAP + BIO-C repair Group 3: 3a : Calcium hydroxide + diH2O + MTA 3b : Calcium hydroxide + diH2O + MTA-HP 3c : Calcium hydroxide + diH2O + ERRM 3d : Calcium hydroxide + diH2O + BIO-C repair Group 4 : 4a : Calcium hydroxide + CHX + MTA 4b : Calcium hydroxide + CHX + MTA-HP 4c : Calcium hydroxide + CHX + ERRM 4d : Calcium hydroxide + CHX + BIO-C repair	Different intracanal medicaments have the same effect on the bond strength of calcium silicate-based materials. Also, ERRM and BIO-C repair show the best bond strength qualities while on the contrary MTA and MTA-HP cements present the lowest outcomes.
Yaghmoor, R.B., et al. (2020) [74]	Effect of Hydrogel-Based Antibiotic Intracanal Medicaments on Push-Out Bond Strength	Intact, single, straight, and conical-rooted human teeth	144	Group 1a: no-intracanal treatment control group + MTA Group 1b: no- intracanal treatment control group + Biodentine Group 1c: no- intracanal treatment control group + Endosequence putty cement Group 2a: Ca(OH)2 + MTA Group 2b: Ca(OH)2 + Biodentine Group 2c: Ca(OH)2 + Endosequence putty cement Group 3a: typical clinical concentration of TAP (1,000 mg/mL) + MTA Group 3b: typical clinical concentration of TAP (1,000 mg/mL) + Biodentine Group 3c: typical clinical concentration of TAP (1,000 mg/mL) + Endosequence putty cement Group 4a: low concentration TAP loaded into a methylcellulose system (1 mg/mL) + MTA Group 4b: low concentration TAP loaded into a methylcellulose system (1 mg/mL) + Biodentine Group 4c: low concentration TAP loaded into a methylcellulose system (1 mg/mL) + Endosequence putty cement Group 5a: typical clinical concentration DAP (1,000 mg/mL) + MTA Group 5b: typical clinical concentration DAP (1,000 mg/mL) + Biodentine Group 5c: typical clinical concentration DAP (1,000 mg/mL) + Endosequence putty cement Group 6a: low concentration DAP loaded into a methylcellulose system (1 mg/mL) + MTA Group 6b: low concentration DAP loaded into a methylcellulose system (1 mg/mL) + Biodentine Group 6c: low concentration DAP loaded into a methylcellulose system (1 mg/mL) + Endosequence putty cement	-1 mg/mL DAP had significantly higher bond strength while used with Biodentine compared to MTA and endosequence (endosequence > mta) - no difference between three cement types while using Ca(OH)2 and 1 mg/mL TAP -in the 1,000 mg/mL TAP and DAP groups, bond strength of Endosequence putty and Biodentine were significantly higher than MTA (no significant difference between biodentine and Endosequence) Endosequence putty had much higher bond strength than MTA and Biodentine in the control group -control group had lower bond strength than others -while using MTA best bond strengths belonged to Ca(OH)2 , 1 mg/mL DAP, and TAP groups -while using Biodentine, 1 mg/mL DAP group was the best option - while using Endosequence putty, 1 mg/mL DAP group (then Ca(OH)2 group) showed the best results - 1 mg/mL of DAP loaded into a hydrogel methylcellulose system and Ca(OH)2 did not lower the bond strength of calcium silicate-based cement to radicular dentin.

Table 1- Related articles from 2000 to 2023

Author	Title	Tooth type	Tooth no	Groups	Results
Brindha L (2020) [75]	Comparative Evaluation of the Effect of Various Intracanal Medicaments on the Push-out Bond Strength of MTA and Endocem MTA - An In Vitro Study	Human maxillary anterior teeth	90	Group 1 : 1a : Calcium hydroxide with distilled water + MTA 1b : Calcium hydroxide with distilled water + Endocem MTA Group 2 : 2a : (Antibiotic + Steroid paste) + MTA 2b : (Antibiotic + Steroid paste) + Endocem MTA Group 3: 3a : Saline (control) + MTA 3b : Saline (control) + Endocem MTA	Calcium hydroxide as an intracanal medicament has sufficient effects on the bond strength of MTA and Endocem MTA. Also, comparing MTA and Endocem MTA regardless of the intracanal medicament used, Endocem MTA turns out to have superior bond strength.
Grazziotin-Soares R, Dourado L, et al. (2020) [48] *experimented with Micropush-out test	Dentin Microhardness and Sealer Bond Strength to Root Dentin are Affected by Using Bioactive Glasses as Intracanal Medication	palatal roots of human first maxillary molars	32	Group 1 : NbG(niobium phosphate bioactive glass) + MTA Fillapex Group 2 : 45s5 bioactive glasses) + MTA Fillapex Group 3 : Ca(OH)2 + MTA Fillapex Group 4 : control + MTA Fillapex	The results indicate that NbG and 45s5 do not affect the bond strength when using MTA Fillapex
Alsubait S, Alsaad N (2020) [76]	The effect of intracanal medicaments used in Endodontics on the dislocation resistance of two calcium silicate-based filling materials (MTA & TotalFill BC)	Human mandibular premolars	45	Group 1a: mTAP / MTA Group 1b: mTAP / BC putty Group 2a: Ca(OH)2/ MTA Group 2b: Ca(OH)2/ BC putty Group 3a: no intracanal / MTA Group 3b: no intracanal /BC putty	-no significant difference in bond strength between MTA & BC in the control group (C1 – C2) -significant decrease in bond strength when using MTA with medicament, regardless of the type of intracanal medicament used - no effect on BC bond strength
Al-Haddad A, Kacharaju K, et al. (2020) [77]	Effect of Intracanal Medicaments on the Bond Strength of Bioceramic Root Filling Materials to Oval Canals	single-rooted human mandibular premolars	30	Group 1 : 1a : No intracanal medicaments (control group) + iRoot SP 1b : No intracanal medicaments (control group) + OrthoMTA Group 2 : 2a : DiaPex® Plus (Calcium hydroxide, Diadent Group International, Korea) + iRoot SP 2b : DiaPex® Plus (Calcium hydroxide, Diadent Group International, Korea) + OrthoMTA Group 3 : 3a : Odontopaste® (Australian Dental Manufacturing, Kenmore Hills, Qld, Australia) + iRoot SP 3b : Odontopaste® (Australian Dental Manufacturing, Kenmore Hills, Qld, Australia) + OrthoMTA	Applying Diapex does not affect the bond strength of OrthoMTA and iRoot SP, however, Odontopaste causes higher bond strength when using iRoot SP. Odontopaste has no notable effect on the bond strength of OrthoMTA.
Gupta A, Kumar M, et al. (2020) [78]	Effect of intracanal calcium hydroxide dressing on the push out bond strength of AH Plus, MTA Fillapex®, and endosequence BC sealer	Single-rooted human mandibular premolars	40	Group 1: 1a : Calcium hydroxide + MTA Fillapex 1b : no intracanal medicament + MTA Fillapex Group 2 : 2a : Calcium hydroxide + endosequence BC sealer 2b : no intracanal medicament + endosequence BC sealer	The use of calcium hydroxide medicament (ApexCal) resulted in a significant decrease in push-out bond strength. Push-out bond strength also decreased when moving from the cervical to the apex of the root. Regardless of the medicament used the order of push-out bond strength results were as: Endosequence BC sealer > MTA Fillapex

Table 1- Related articles from 2000 to 2023

Author	Title	Tooth type	Tooth no	Groups	Results
Pereira, A.C., et al. (219) [79]	Effect of intracanal medications on the interfacial properties of reparative cements	lower human premolars (straight, single canals)	70	Group 1a: calcium hydroxide P.A. with chlorhexidine gel (2%) + White MTA Angelus (WMTA) Group 1b: calcium hydroxide P.A. with chlorhexidine gel (2%) + Biodentine Group 2a: TAP + WMTA Group 2b: TAP + Biodentine Group 3a: calcium hydroxide P.A. with distilled water + WMTA Group 3b: calcium hydroxide P.A. with distilled water + Biodentine Group 4a: no intracanal + WMTA Group 4b: no intracanal + Biodentine	-Biodentine had higher bond strength than WMTA(regardless of the medicament) -intracanal medications had no significant effect on bond strength of WMTA except for TAP. - intracanal medications had no significant effect on Biodentine bond strength.
Jain P, Nanda Z (2019) [80]	Effect of acidic environment and intracanal medicament on push-out bond strength of biodentine and mineral trioxide aggregate plus: an in vitro study	single-rooted sound human teeth	40	Group 1: No acidic environment + Ca(OH)2 1a:MTA plus 1b:biodentine Group 2: acidic environment + Ca(OH)2 2a:MTA plus 2b:biodentine Group 3: No acidic environment + No intracanal medicament used 3a:MTA plus 3b:biodentine Group 4: acidic environment + No intracanal medicament used 4a:MTA plus 4b:biodentine	-decrease in bond strength when the environment pH is low in both MTA and biodentine- no difference in biodentine and MTA plus bond strength
Oktay EA, Ersahan S (2018) [81]	Effect of intracanal medicaments used in endodontic regeneration on the push-out bond strength of a calcium-phosphate-silicate-based cement to dentin (ERRM)	single-rooted human teeth	50	Group1: CH + ERRM Group2: DAP + ERRM Group3: TAP + ERRM Group4: mtap + ERRM Group5(control): no medicament + ERRM (EndoSequence Root Repair Material)	- CH clinically has higher bond strength than other - CH improves the adhesion of calcium-phosphate silicate-based cement to dentin
Nagas E, Cehreli ZC (2016) [82]	Effect of several intracanal medicaments on the push-out bond strength of ProRoot MTA and Biodentine	maxillary anterior teeth	60	Group1: calcium hydroxide (CH) powder mixed with distilled water 1a:ProRoot MTA 1b:Biodentine Group2: triple antibiotic paste) 2a:ProRoot MTA 2b:Biodentine Group3: a combination of amoxicillin and clavulanic acid (Augmentin) 3a:ProRoot MTA 3b:Biodentine Group4: an antibiotic-corticoid compound paste(Ledermix) 4a:ProRoot MTA 4b:Biodentine Group5: no medicament (control) 5a:ProRoot MTA 5b:Biodentine	- highest push-out bond strength was gained when treated with CH -regardless of intracanal medicaments, Biodentine had higher bond strength than MTA.
Reyhani MF, Zand V (2017) [83]	Effect of calcium hydroxide mixed with different vehicles on the push-out bond strength of mineral trioxide aggregate	Human maxillary anterior teeth	80	Group1: calcium hydroxide and distilled water Group2: calcium hydroxide and propylene glycol Group3: calcium hydroxide and chlorhexidine 0.2% Group4: control	-maximum bond strength: propylene glycol Minimum:distilled water

Discussion

Previous reviews have examined how intracanal medicaments influence the bond strength of dental materials, particularly adhesives used in fiber-post treatment.[84,85,86,87] In contrast to these studies, the present review focused on evaluating their

impact specifically on silicate-based cement, which holds significant importance in endodontics. Exploring this relationship further is crucial to enhance the bond strength of cement when used alongside root canal medicaments.

Most reviews indicate that the use of intracanal medicaments enhances the bond strength of silicate-based cement. Calcium hydroxide has been found to yield the highest bond strength among all intracanal medicaments.[69,79,80] Studies consistently show that Biodentine, EndoSequence Root Repair Material, Bio-C repair, and Endocem MTA exhibit higher bond strength compared to MTA, irrespective of the intracanal medicament used.[71,73,80] According to some findings, using 1 mg/ml of double antibiotic paste (DAP) results in the highest bond strength with Biodentine. EndoSequence follows Biodentine in second place, with MTA ranking third.[72] Additionally, applying 1000 mg/ml of triple antibiotic paste (TAP) significantly enhances bond strength in Biodentine and EndoSequence compared to MTA.[72] To achieve maximum bond strength with MTA, the combination of calcium hydroxide with propylene glycol, 1 mg/ml of DAP, and TAP has been recommended.[72,81] In addition to the results above, some less-known medicaments, such as NbG and 45s5, positively affect MTA Fillapex bond strength.[47] Also, odontopase with iRoot SP can increase bond strength.[75] Furthermore, bioceramic intracanal positively affects bioceramic sealers.[68]

However, several studies offer conflicting results that challenge the aforementioned findings. Some indicate that intracanal medications have no effect on the bond strength of Biodentine and certain other sealers.[70,77] Additionally, one study suggests that the use of calcium hydroxide reduces the bond strength of MTA Fillapex and EndoSequence BC sealer.[76] The topic requires additional research.

Conclusion

Examining the influence of intracanal medicaments on dental cement properties can significantly improve endodontic treatment outcomes. For instance, combining TAP with Biodentine and EndoSequence enhances bond strength more effectively than with MTA alone. Additionally, combining MTA with medicaments like calcium hydroxide, DAP, and TAP can maximize bond strength. In conclusion, the insights from this study can assist dental professionals in leveraging the advantages of intracanal medicaments, such as root canal disinfection, while optimizing the push-out bond strength of commonly used dental cements.

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