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Evaluation of Intracanal Medicaments on Pushout Bond Strength of Calcium Silicate Based

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Keywords
Intracanal medicaments, Apical plug, Biodentine, MTA, pushout bond strength, Sealing Ability

Abstract
Background: The disinfection of canal and optimal coronal and apical seal forms the mainstay for success of any endodontic treatment. Cements made of calcium silicate, such as Biodentine and Mineral Trioxide Aggregate (MTA), are gaining popularity as apical plug restorations. However, their pushout bond strength can be affected by the intracanal medicaments used due to the surface changes they produce on root dentin.
Aim: To assess the impact of medications for intracanal use such as Calcium Hydroxide (CH) and Triple Antibiotic Paste (TAP) placed for different time periods on the pushout bond strength (PBS) of MTA and Biodentine.
Materials and Methodology: One hundred single rooted teeth were prepared to simulate open apex. Teeth were divided into 5 groups (n = 20) namely CH for 1 week, TAP for 1 week, CH for 3 weeks, TAP for 3 weeks and a control group. 2mm discs were prepared from each specimen and filled with MTA and Biodentine and subjected to universal testing machine for measuring the values of pushout bond strength in Mega pascals. Collected data was subjected to statistical analysis. Tests used were ANOVA and post hoc Tukey.
Results: The result between all the groups was statistically highly significant and group 3b (CH- 3 week + BD) showed highest pushout bond strength and the least push out bond strength was observed in group 5a (control + MTA). The higher pushout bond strength was observed when the CH was used as an intracanal medicament. The pushout bond strength of the apical plugs improved when the intracanal medicaments were used for a longer duration of 3 weeks than the 1-week application.
Conclusion: The use of TAP as intracanal medicament for 3 weeks and Biodentine as apical plug material can be recommended for one visit apexification technique as they have a higher pushout bond strength.

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1. Introduction

Owing to inadequate apical constriction present naturally and weak root walls, teeth with necrotic pulp and open apex present a number of difficulties for physicians. Therefore, endodontic, reparative, and restorative difficulties can arise during root canal therapy for teeth that are still developing.[1]

The persistence of germs and their growth in the root canal system are detrimental to the outcome of endodontic therapy. The root canal system was effectively disinfected using a number of intracanal medications. The most popular intracanal medication in endodontics is calcium hydroxide because it has antibacterial properties and can promote the creation of hard tissue.[2] Recently, the use of Triple Antibiotic Paste (TAP), a concoction of ciprofloxacin, metronidazole, and minocycline, to clean developing teeth, has been suggested. [3]

"Apexification is defined as a method to induce a calcific barrier in a root with an open apex or a continuous apical development of anincomplete root in necrotic pulp teeth".[4] Due to benefits including great sealing capability, good compressive strength, and good biocompatibility, a single visit apexification procedure using Mineral Trioxide Aggregate (MTA) as an osteoconductive apical barrier is becoming more and more well-liked. MTA does have some important drawbacks, too, including lengthy timing, challenging handling characteristics, expensive cost, and discolouration.[5] In order to address the shortcomings of MTA, a new calcium silicate-based material known as Biodentine (Septodont, Saint Maur des Fossés, France) was later released in the market. Due to its quicker 12-minute setting time and biocompatibility, Biodentine has the potential to be used as dentinal substitute in a variety of clinical situations. [6]

Apical plug characteristics, such as bond strength of the endodontic medication, are crucial for the effective endodontic treatment of teeth with open apex. Various research has been done in the past to assess the impact of pH, smear layer removal, apical plug thickness, blood contamination, and different mixing processes on the ability of the material to seal the canal and bond strength of plugs placed apically when subjected to pushout forces.[7-8] Only a few studies, though, have been done to show how an intracanal medication affects the pushout bond strength of apical plugs when it is inserted for various lengths of time.

Placement of calcium hydroxide as an intracanal medicament reduces the micro tensile fracture strength and the fracture resistance of the dentin. Triple antibiotic pastes cause reduction in the microhardness of the dentin, which might be due to the demineralizing effect of the antibiotic mixture on dentin.[9] There exists a gap in literature regarding the effects of medicament placed for different time frames on the physical properties like pushout bond strength of apical plugs.

The aim of this study was therefore to evaluate the push-out bond strength of the apical plugs of MTA and Biodentine after placement of Triple Antibiotic Paste and Calcium Hydroxide for 1 week and 3 weeks.

2. Material and Methodology:

Ethical consideration: After receiving previous approval from the institution's Ethical Committee, this study was conducted in the Department of Pediatric and Preventive Dentistry, Karnavati School of Dentistry, Uvarsad, Gandhinagar, Gujarat.

Study design: This was a comparative in-vitro study that examined how intracanal medications affected the apical plugs' bond strength when subjected to pushout forces during the simulated apexification surgery.

Teeth selection: A total of 100 single rooted teeth extracted due to poor periodontal conditions were included in the study.

Inclusion criteria: • Single rooted teeth with single root canal. • Teeth extracted due to the periodontal conditions.

Exclusion criteria: • Teeth which were extracted due to cause other than periodontal conditions. • Teeth with several root canals and multiple roots • Teeth with root caries. • Teeth with internal or external root resorption. • Teeth with any dental anomalies.

Specimen preparation: All organic buildup and deposits were removed from the 100 included teeth using an ultrasonic scaler, and they were then cleaned, preserved in 10% formalin, and ready for use. To standardize the working length of the specimen to 121 mm, their coronal portions were remove till the level

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of cementoenamel junction and the tip of root was excised with the aid of a diamond disc. Then, by manually inserting the #15 K-file (Mani, Japan) through the canals until the points of the files were visible in the apical foramen, the actual working length was determined. Root canal preparations were conducted with HeroShaper rotary instruments up to 25.06-degree taper files at 300 rpm and 2 Nm torque after instrumentation with hand files up to #20. 2.5% NaOCl and 0.9% normal saline were employed as an irrigation regimen throughout each file transfer, and 17% EDTA was used as lubricant while the root canal was being prepared. After rotary instruments were used to prepare the root canals, the Gates-Glidden drills #4, #5, and #6 were used to standardize the 1.5 mm diameter for root canals and to drill 1 mm past the apex to resemble the open apex. After cleaning five canals with each tool, it was changed, or if any signs of distortion were noticed. The smear layer was eliminated by flushing the canal with 10 mL ethylenediaminetetraacetic acid (EDTA) in concentration of 17% for 1 min and 2.5% NaOCl, once the instrumentation procedure was complete. The canals were then dried with sterile paper points after being rinsed with 20 mL of sterile saline to remove any remaining irrigant. All of the specimens were prepared by a single operator.

Application of intracanal medicament: According to the amount and kind of intracanal medications used, samples were separated into five groups of 20 samples:

Group 1: Calcium Hydroxide for 1 week

Group 2: TAP for 1 week

Group 3: Calcium Hydroxide for 3 weeks

Group 4: TAP for 3 weeks

Group 5: Control group- no medicament

On a glass slab, regular saline and chemically pure CH powder were combined at a 1:1.5 powder to liquid ratio. Equivalent amounts of the antibiotics Metronidazole 400 mg (J.B. Chemicals and Pharmaceuticals Ltd.), Minocycline 100 mg (Sun Pharmaceuticals Industries Ltd.), and Ciprofloxacin 500 mg (Cipla Ltd.) were combined with distilled water with a 3:1 powder to liquid ratio to create Triple Antibiotic Paste (TAP). Using a lentulo spiral paste holder and a slow speed contra-angled handpiece, sterile paper points having blunt ends were used to inject both drugs into the root canals and push them down in the canal space. Control group had no intracanal medication. According to the group assigned, the specimens were kept in sponges that had been soaked in distilled water for one or three weeks in an incubator at 37 °C and 95% humidity.

Pushout bond strength testing:

A total of 100 teeth were subjected to testing for pushout bond strength. After removal of intracanal medicaments, 2 mm thick slices were prepared from each specimen tooth. As a result, a total of 100 discs were obtained. Biodentine and MTA were mixed according to the instructions of the manufacturer. The test materials were placed in the lumen of the discs. The materials were condensed using endodontic hand plugs and placed on a glass slab. The excess material from the discs was removed with scalpel. After placement of MTA and Biodentine, all specimens were stored in 100% humidity for 24hours. After 24 hours, all specimens were subjected to push-out bond strength. The push-out bond strength was measured using the Universal Testing Machine (Instron, Canton, MA, USA). The samples were set on a metal ring with a hole in the centre so the plunger could move freely (Figure 1). With help of a probe moving at a speed of 1 mm/min constantly, a downward pressure was applied to the test material's surface in each sample to simulate a compressive force. To guarantee that it only made touch with the materials to be tested, clearance of plunger was 0.2 mm from end of the dental wall. Amount of force that was exerted to test materials when they were dislodged (Figure 2) was measured in newtons. By dividing this force with test material's surface area, the push-out bond strength was determined. Unit used for its measurement was MegaPascals (MPa).

Final Sample distribution for pushout bond strength testing:

100 Samples were distributed into 10 groups of 10 each for the pushout bond strength testing. Group-1a: CH- 1 week + MTA (n=10) Group-1b: CH- 1 week + BD (n=10) Group-2a: TAP- 1week + MTA (n=10) Group-2b: TAP- 1 week + BD (n=10) Group-3a: CH- 3 week + MTA(n=10) Group-3b:

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CH- 3 week + BD (n=10) Group-4a: TAP- 3 week + MTA (n=10) Group-4b: TAP- 3 week + BD (n=10) Group-5a: control (no medicaments) + MTA (n=10)Group-5b: control (no medicaments) + BD (n=10).

Figure-1: Placement of plunger headfor pushout bond test

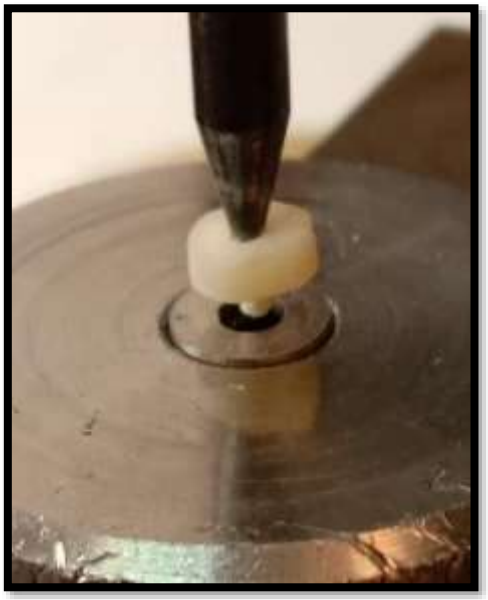

Figure-2: Displacement of apical plug

Table 1: Intergroup Comparison of Mean Bond Strength

Group	N	Minimum	Maximum	Mean	Std. Deviation	P value
Group 1a	10	7.57	9.54	8.4340	.61156	<0.001**
Group 1b	10	10.02	14.51	11.7960	1.27192	

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Group 2a	10	5.16	8.92	7.0530	1.08880
Group 2b	10	7.73	11.21	9.2870	1.04853
Group 3a	10	8.92	10.91	9.8570	.79051
Group 3b	10	9.43	14.03	12.2910	1.64672
Group 4a	10	7.37	10.63	8.4610	1.09975
Group 4b	10	7.71	11.32	9.4190	1.11513
Group 5a	10	3.86	5.47	4.3830	.53037
Group 5b	10	5.89	8.46	6.6590	.81884

**-Highly significant (p<0.001)

Table 2: Order of Bond Strength

Group	N	Subset for alpha = 0.05				
		Least	Low	Medium	High	Highest
Group 5a	10	4.3830				
Group 5b	10		6.6590			
Group 2a	10		7.0530			
Group 1a	10			8.4340		
Group 4a	10			8.4610		
Group 2b	10			9.2870	9.2870	
Group 4b	10			9.4190	9.4190	
Group 3a	10				9.8570	
Group 1b	10					11.7960
Group 3b	10					12.2910

Table 3: Comparison of Mean Bond Strength between MTA and Biodentine inrespective ICM and time duration

Comparison between		Mean 1	Mean 2	Mean Difference	P value
Group 1a	Group 1b	8.43	11.80	-3.36	<0.001**
Group 2a	Group 2b	7.05	9.29	-2.23	<0.001**

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Group 3a	Group 3b	9.86	12.29	-2.43	<0.001**
Group 4a	Group 4b	8.46	9.42	-0.95	0.044*
Group 5a	Group 5b	4.38	6.66	-2.27	<0.001**

**-highly significant (p<0.001), *-Significant (p<0.05)

Table 4: Intergroup Comparison of Bond Strength in CH intracanalmedicament at 1 and 3 weeks

Comparison between		Mean 1	Mean 2	Mean Difference	P value
Group 1a	Group 1b	8.43	11.80	-3.36	<0.001**
Group 1a	Group 3a	8.43	9.86	-1.42	0.003*
Group 1a	Group 3b	8.43	12.29	-3.85	<0.001**
Group 1b	Group 3a	11.80	9.86	1.93	<0.001**
Group 1b	Group 3b	11.80	12.29	-0.49	0.294 NS
Group 3a	Group 3b	9.86	12.29	-2.43	<0.001**

**-Highly significant (p<0.001), *-Significant (p<0.05), NS – Not significant(p>0.05)

Table 5: Intergroup Comparison of Mean Bond Strength in TAP intracanalmedicament at 1 and 3 weeks

Comparison between		Mean 1	Mean 2	Mean Difference	P value
Group 2a	Group 2b	7.05	9.29	-2.23	<0.001**
Group 2a	Group 4a	7.05	8.46	-1.40	0.003*
Group 2a	Group 4b	7.05	9.42	-2.36	<0.001**
Group 2b	Group 4a	9.29	8.46	.83	0.082 NS
Group 2b	Group 4b	9.29	9.42	-.13	0.779 NS
Group 4a	Group 4b	8.46	9.42	-0.95	0.044*

NS – Not significant (p>0.05), *-Significant (p<0.05), **-Highly significant(p<0.001)

3. Result:

One-way analysis of variance of pushout bond strength in MPa with mean and standard deviation between all the groups is shown in Table 1. The result between all the group was statistically highly significant. In group 3b (CH- 3 week + BD) highest pushout bond strength was observed, and minimum was observed in group 5a (control + MTA). One-way ANOVA found statistically highly significant difference amongst all the groups.

The order of pushout bond strength from greatest to least showed that the biodentine subgroups performed better and the control group with MTA had the least pushout bond strength (Table 2).

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Table 3 shows the comparison of mean pushout bond strength of MTA and Biodentine in same medicament group and same time duration group. The result of this study shows that Biodentine had higher pushout bond strength as compared to MTA in all the intracanal medicament groups. The statistically significant difference was observed in all the intracanal medicament and time duration.

Intergroup comparison between all the calcium hydroxide medicament group at 1 week and 3-week time duration is shown in Table 4. This table shows that statistically significant difference was found in all the group comparison except when the group 1b (CH- 1 week + BD) was compared with group 3b (CH- 3 week + BD). This describes that the application of calcium hydroxide medicament for regardless of time period for which it is applied, increased the pushout bond strength. Also, the Biodentine apical plug showed higher pushout bond strength than the MTA. Table 5 shows the intragroup comparison between all the TAP medicament group at 1 week and 3-week time duration. This table shows that results differed statistically between all other groups except when the group 2b (TAP- 1 week + BD) was compared with group 4a (TAP- 3 week + MTA) and group 4b (TAP- 3 week + BD). This describes that the application of 3 weeks intracanal medicament of TAP resulted in the increased pushout bond strength as compared to application of 1 week. Also, the TAP medicated group resulted in higher pushout bond strength with the apical plugs of Biodentine than in MTA.

4. Discussion:

Up to 3 years after the tooth's eruption, the root's development is finished, and the root apex closes. Children between the ages of 8 and 9 are more likely to suffer acute dental injuries to permanent incisors, which have not yet fully developed roots.[10] In addition to trauma, decay in developing permanent teeth and/or developmental flaws like Dens Invaginatus (Dens in Dente) or Dens Evaginatus that cause pulpal exposure or pupal involvement prior to the completion of root formation are other potential causes of incomplete root development.[11]Dental professionals face a clinical conundrum when treating necrosed teeth with open apexes using endodontic procedures. For this kind of clinical circumstance, there are different therapy modalities that combine surgical and non-surgical methods. Apexification and revascularization are two treatment techniques that can be carried out non-surgically.

Mineral Trioxide Aggregate was found in 1993 by Torabinejad[12] and was given the go-ahead by the FDA in 1998. Since then, the material of choice for a single-visit apexification has been MTA. In their description of the MTA approach, according to Witherspoon and Ham, MTA has the ability to enhance biological seal and provides a scaffold for the creation of hard tissue.[13] They came to the conclusion that this method is an effective substitute for calcium hydroxide for the treatment of young permanent teeth with necrotic tissue. However, MTA has considerable drawbacks, including a long setting time, challenging handling qualities, a high price, and discoloration. When the tooth's natural dentin is compromised, Biodentine, a biologically active dentin substitute, can be used as a permanent dentin replacement. In the case of apexification, a shorter setting time decreases the possibility of bacterial contamination by doing away with the necessity for two-step obturation, as with MTA.[14] Therefore, in our investigation, the marginal adaptability of these two calcium silicate materials to root dentin following intracanal medication placement was evaluated.

The intracanal medicaments are used to minimize bacterial infections from the canal and also for the conditioning of the dentinal surface of the root canal. In the present study two different medicaments, Calcium hydroxide and triple antibiotic pastes were used. Calcium hydroxide in powder form used and sterile water was used as a vehicle. Triple antibiotic combination was used as suggested by Hoshino et al in 1:1:1 formula. Both the intracanal medicaments were mixed with sterile water to solely assess the effects of the intracanal medicaments rather than the other vehicles and were placed using the lentulo spiral paste carriers. After the placement of intracanal medicaments, the samples were stored in 100% humid environment for the stipulated time period of 1 week and 3 weeks. To attain 100% humid environment water-soaked sponge were used, and this procedure was carried out for 1 week and 3 weeks simultaneously according to the distribution of the test groups.

Pushout bond strength refers to force required to dislocate the dental material. It is also known as dislocation resistance. To compare the bonding strengths of MTA and Biodentine after root treatment

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with medicaments like CH and TAP, the push-out test was used in the current investigation. The dislocation resistance of MTA and Biodentine has been reported to be impacted by the physical characteristics of the contacting dentin surface, thickness, time of assessment, moisture content of the surrounding tissues, and environmental pH.[15,16] Regenerative treatment of the root canals make them vulnerable to different irrigating solutions and medicaments used to render canal infection free. This can lead to changes in the chemical as well as mechanical properties of root canals. Thus, it has become crucial to study the resistance to dislocation forces for both: MTA and Biodentine. The findings of this investigation indicated that the type of medication utilised affected the dislocation resistance of MTA and Biodentine.

In the present study, the pushout bond strength of Biodentine was significantly higher than that of the MTA. This result was in accordance with the study by Guneser et al who found that the bond strength of MTA was weaker than that of the Biodentine.[17] In addition, according to Ma'atta et al., the binding strength of Biodentine was higher than that of MTA because it has smaller particles and a greater capability for penetration into the dentinal tubules.[15]

Our analysis revealed that cement adhesion to dentin-treated CH was superior to cement adherence to TAP with dentin treatment. The improvement can be due to either the reaction of calcium with leftover CH or conversion to calcium carbonate. Therefore, in the current investigation, the positive results in calcium hydroxide group could be attributed to the calcium ions created by residual material, which have formerly been proposed to promote MTA and Biodentine adherence.

In this study, dislocation resistance in the Triple Antibiotic Paste Group was increased. Effects of antibiotics on dentin have been evaluated by Yassen et al[18] and have been found to have a demineralizing effect due to its acidic pH. It produces surface irregularities due to the lower pH that could be responsible for increasing the MTA and Biodentine bond strength of the push-out group. Ions are leached during reaction of MTA and BD with root dentin, with Ca++ being the most prevalent.[19] This causes the hydroxyapatite or carbonated apatite interfacial layer to develop, which is crucial for biomaterials like chemical bonding.[20]

In this study, the Biodentine group showed significantly higher bond strength than the MTA in all drug groups. This discovery supported the findings of earlier research that contrasted the binding strengths of MTA as well as BD under various experimental setups.[15,16] Both substances have been shown to generate an interfacial layer and mineral structure resembling a tag that extends to the dental tubules.[20,21] However, some differences have been reported in the layers between the facial surfaces created by MTA as well as BD. According to Han and Okiji[21], BD produced more precipitates of calcium phosphate, more Ca++ ions, and thicker calcium-rich dentinal areas in contrast to MTA.

In the present study, in all of the CH and TAP intracanal medicament group tested, improved push-out bond strength was demonstrated at 3-week application compared to 1-week application. The reason for higher pushout bond strength in CH intracanal medicament may be the release of Ca++ into the root canal, which provided additional BD and MTA adhesion to the dentin. In the TAP group, increased BD and MTA bond strength may be attributed to the acidic environment provided, which caused surface irregularities leading to better adhesion.

Placement of intracanal medicaments did not have any harmful effects on physical properties, as both CH and TAP reduced dislocation capabilities of MTA and Biodentine as compared to control group. The long duration (3 weeks) of both intracanal medicament compared to 1 week increased the push-out bond strength of both MTA and Biodentine.

LIMITATION:

This study was an in vitro study, and it is difficult to imitate the environment of the oral cavity and the temperature changes of the oral cavity might influence the result.

5. Conclusion:

The following conclusions can be made given the limitations of this study:

1. The higher pushout bond strength was observed when the CH was used as an intracanal medicament. This can be due to its effect on the surface of dentin that forms micromechanical tags of MTA and BD.

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2. The pushout bond strength of the apical plugs improved when the intracanal medicaments were used for a longer duration of 3 weeks than the 1-week application.

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