

The Efficacy of Intracanal Calcium Hydroxide and Amoxicillin Containing Triple Antibiotic Paste on the Push Out Bond Strength of AH Plus BC Sealer - An *Ex Vivo* Study

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ABSTRACT

Objectives: The aim of the study is to evaluate and compare the effect of calcium hydroxide (CH) and amoxicillin containing triple antibiotic paste (TAP) on the push out bond strength of AH plus BC sealer at coronal, middle and apical third of the root.

Materials and Methods: A total of 45 single rooted premolars were decoronated and instrumented by a Pro Taper rotary system up to F3. The samples were randomly divided into three groups according to the intracanal medicament used (n=15): Group A = No medicament, Group B = Calcium hydroxide and Group C = Amoxicillin containing Triple antibiotic paste. After three weeks of medicament placement, the specimens were irrigated by 10 mL 17% EDTA, followed by 10 mL 2.5% NaOCl and an ultimate flushing by 5 mL of distilled water. The samples were obturated using AH-Plus BC sealer and gutta-percha by single cone obturation technique. After obturation, 2 mm thick slices were obtained from three sections of the canal (coronal, middle, and apical). A push-out test was performed using universal testing machine to measure the bond strength between the root canal dentin and the sealer.

Results: The push-out bond strength of AH Plus BC sealer was notably influenced by the type of intracanal medicament used. Bond strength was nearly twice as high following the application of Amoxicillin containing triple antibiotic paste (TAP) compared to calcium hydroxide (CH), and these results were independent of the position along the canal.

Conclusions: Calcium hydroxide (CH) had no impact on the bond strength of the AH plus BC sealer. Furthermore, using Amoxicillin containing triple antibiotic paste (TAP) rather than calcium hydroxide (CH) enhances the bond strength of AH plus BC sealer throughout the root canal.

Keywords: Bond strength, AH plus BC sealer, calcium hydroxide, Amoxicillin containing triple antibiotic paste.

INTRODUCTION

The ultimate goal of root canal treatment is the elimination of bacteria and they're by products from the root canal and to seal the root canal once it has been disinfected. ⁽¹⁾ The

combined use of instruments, various irrigation solution, and intracanal medications has been suggested as the best method for disinfecting an infected root canal system. ⁽²⁾

Calcium hydroxide (CH) is widely used as intracanal medicament throughout the world. (2) It plays an important role in endodontics due to its antibacterial effect, biocompatibility, tissue-dissolving capability, potency to inhibit inflammation and osteoclastic activity. (3)

In recent years, the use of Triple antibiotic paste (TAP) in endodontic treatment has become increasingly popular. TAP is a mixture of ciprofloxacin, metronidazole, and minocycline. (4) It has been shown to have an excellent antibacterial effect, biocompatibility and low toxicity. (2)

Despite these positive features, several case reports have shown that minocycline causes visible crown discolouration and changes in the physical/mechanical properties of radicular dentin. It is cytotoxic to human periodontal ligament fibroblasts, leading to a decrease of cell viability value. Also, it is difficult to remove from the canals, even when using different irrigation solutions. (5)

Due to these disadvantages of TAP with minocycline, TAP with amoxicillin is used because of broader spectrum of antibacterial activity. It has better antimicrobial effect against *Enterococcus faecalis*. It significantly increases the zones of inhibition. It is absorbed more rapidly and no discolouration is seen. (6)

The use of root canal sealers is an essential step in endodontic treatment to ensure that the canal is adequately filled and to prevent microleakage of endodontic treatment. (7) AH plus BC sealer is a combination of resin and bioceramic sealer. They are more radiopaque, has shorter setting time and exhibits low solubility. (8) They have been reported to be biocompatible, gap-free, convenient, has better wash-out resistance and exhibits higher cytocompatibility. (8)(9)

The push-out bond strength is commonly used to evaluate bond strength between sealer and root dentin. It is important to maintain the integrity of the root canal seal. Also minimizes the risk of filling detachment from dentin during restorative procedures or the masticatory function ensuring that

sealing is maintained and consequently clinical success of endodontic treatment. (10)

The use of intracanal medicaments like CH or TAP produce superior retention of root canal fillings with a variety of sealers. It has the potential to improve the adhesion of sealers during endodontic treatments. (2) The mechanism behind the different responses to TAP or CH may reside in the ability to remove after treatment and their interaction with the dentin. (2)(4)

TAP appears to have high diffusion and retention within the dentin and TAP retains in the root canal regardless of the type of irrigation method used to remove it. On the other hand, most of the CH is adequately removed. (2) Higher mean bond strength values are observed in TAP due the binding of residual minocycline to calcium ions via chelation. (2)(4) But, the high alkalinity of CH can negatively influence on the structure of root canal dentin and disturbs the proper adhesion leading to the decrease in bond strength values. (3)

Thus, the aim of the study is to evaluate and compare the effects of calcium hydroxide and amoxicillin containing triple antibiotic paste on the push out bond strength of AH plus BC sealer.

MATERIALS & METHODS

Specimen selection

This study was conducted using 45 single-rooted premolars that had been stored in normal saline and were used within 6 months of extraction for reasons unrelated to this research. The teeth were confirmed radiographically to have a single root canal without any calcification. The inclusion criteria required the canals to be straight and the apices fully formed. The exclusion criteria included teeth with more than one root canal or apical foramen, prior root canal treatment, internal or external resorption, immature root apices, caries, cracks, or fractures on the root surface, and/or root canal curvature exceeding 10°.

Specimen preparation

The external root surfaces were cleaned using ultrasonic instruments and rinsed with distilled water to eliminate any calculus or soft tissue. The crowns were sectioned at the cemento-enamel junction, and the root length was standardized to 15 mm. Once endodontic access was created, the working length was determined by subtracting 1 mm from the actual root length. The cleaning and shaping of all specimens were carried out with ProTaper Universal rotary files (DENTSPLY) in a crown-down approach, using the instruments SX, S1, S2, F1, F2, and F3. The canals were enlarged to F3 (#30/0.09). After each instrument, the canals were irrigated with 2 mL of 2.5% sodium hypochlorite (Medilise) solution, with 5 mL of saline (Fresenius Kabi India Pvt Ltd) used intermittently. The final irrigation for all samples included 5 mL of 17% EDTA (SHIVAM DENTAL) for 1 minute, followed by 5 mL of 2.5% NaOCl for 1 minute. Finally, the canals were dried using #30 sterile absorbent paper points (DiaDent Group International, Korea).

A total of 100 mg of calcium hydroxide (CH) powder was dispensed and mixed with distilled water to achieve a creamy consistency, using a powder-to-liquid ratio of 1:1.5. The antibiotic mixture (TAP) was prepared by removing the coatings and separately crushing ciprofloxacin (Ciplox 500 mg), metronidazole (Metrogyl 400 mg), and amoxicillin (Cipmox 500 mg) tablets using a mortar and pestle. The resulting powders were weighed individually (100 mg each) and combined with 100 mL of distilled water, mixing until a creamy consistency was obtained, following a powder-to-liquid ratio of 3:1.

Samples were randomly divided into three groups ($n = 45$) according to the intracanal medicament used.

- Group A: No medicament ($n = 15$)
 - Group B: Calcium hydroxide ($n = 15$)
 - Group C: Triple antibiotic paste ($n = 15$)
- Intracanal medicament was introduced into root canals using #40 lentulo spiral.

The coronal access was sealed with small cotton pellets, and the specimens were restored coronally with temporary filling material to prevent leakage. The samples were then placed at 37°C with 100% relative humidity for 21 days to simulate clinical conditions. After 3 weeks, the medicaments were rinsed with 10 mL of 17% EDTA, followed by 10 mL of 2.5% NaOCl. A final irrigation was carried out with 5 mL of distilled water using a 27-gauge conventional irrigation needle. The canals were subsequently dried with sterile absorbent paper points. All specimens were then obturated with AH Plus BC sealer and F3 size Gutta percha using the single-cone obturation technique. The specimens were restored coronally with temporary filling material and incubated at 37°C for 7 days. Each root was then embedded in cold-cure acrylic resin (DPI RR Cold Cure).

Push-out bond strength

Once the sealers had set, each specimen was horizontally sectioned using a diamond disc to create 2 mm thick slices. Three sections were made at depths corresponding to the apical (4 mm), middle (7 mm), and coronal (10 mm) thirds. The apical, middle, and coronal surfaces of each slice were examined under a stereomicroscope to measure the diameter of each hole.

Push-out bond strength testing was performed using a universal testing machine with a crosshead speed of 1 mm/min. Three sets of cylindrical pluggers with diameters of 0.6 mm, 0.7 mm, and 0.8 mm, matching the diameter of each canal third, were used for the push-out test on each tooth. The plugger diameters were selected to be at least 80% of the canal diameter.

The maximum load to fracture was applied until the root filling material was dislodged, and the value was recorded in newtons (N). The bond strength was calculated in megapascals (MPa) by dividing the maximum load (F, in N) by the adhesion area of the root filling (A, in mm²) using the following formula: MPa = F/A.

The parameter A will be calculated with the equation: $A = \pi (r1 + r2) * L$
 where $L = \sqrt{(r1 - r2)^2 + h^2}$
 r1 is the minor radius (coronal radius in mm),
 r2 is the major radius (apical radius in mm), h
 is the thickness of the root section (in mm)
 and $\pi = 3.14$ (constant)

STATISTICAL ANALYSIS

All data are expressed as the mean \pm standard deviation (SD). The three groups were analysed by two-way analyses of variance followed by post-hoc Tukey’s tests using the Statistical Package for Social Sciences [SPSS] for Windows Version 24.0 (Armonk, NY: IBM Corp)

RESULT

The type of intracanal medicament used had a noticeable impact on the push-out bond strength of the AH Plus BC sealer. As presented in Table 1 and Figure 1, calcium hydroxide (CH) showed no significant effect on the sealer’s adhesion. However, the application of amoxicillin containing triple antibiotic paste (TAP) led to a substantial increase in bond strength—nearly doubling the values observed with CH. This enhancement was most prominent in the apical third of the root canal, followed by the middle and then the coronal third, indicating a gradient of improved adhesion from apex to crown.

Table 1: Mean push-out bond strength values (MPa) of the root canal filling material to the root dentin after being treated with different intracanal medicaments according to the root canal thirds

Root Canal Section	Coronal	Middle	Apical
Control	2.562	2.715	3.241
CaOh	2.808	2.981	3.428
TAP	4.627	5.139	5.788

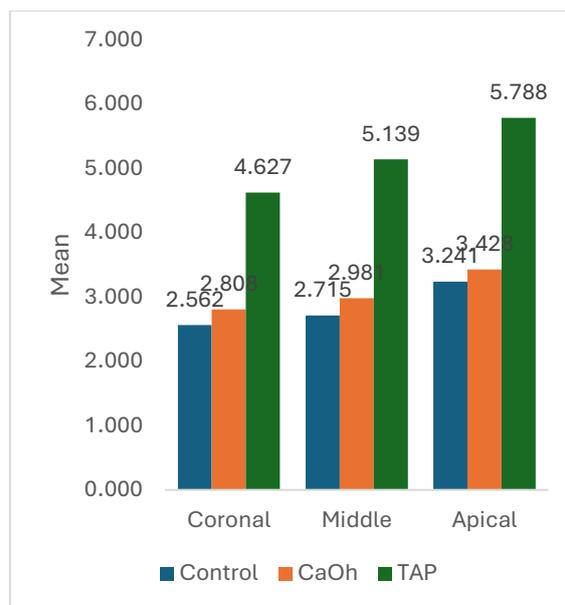


Figure 1: Mean push-out bond strength values (MPa) of sealer to root canal dentin according to the different medicaments and the root canal thirds.

DISCUSSION

Root canal therapy aims to eliminate infection within the root canal system by removing bacteria and their by products, and sealing the canal to prevent re-infection. The complex nature of the canal, with many branches that can harbor bacteria, makes complete disinfection challenging. After cleaning with rotary instruments and antiseptic solutions like sodium hypochlorite, intracanal medications are often used to remove remaining bacteria.^{1,2} Calcium hydroxide (CH) is a commonly used medication due to its antibacterial properties and ability to create a high-pH environment hostile to bacteria.^{12,13} However, root canal infections are often polymicrobial, with some bacterial species resistant to CH. This led to the development of Antibiotic Pastes (TAP), typically containing metronidazole, ciprofloxacin, and minocycline. Due to minocycline’s limitations, amoxicillin and its derivatives are preferred for their broader antibacterial spectrum.⁶ While amoxicillin containing TAP’s antimicrobial effectiveness is well-known, its impact on the adhesion of root canal sealers, particularly bioceramic ones like AH Plus BC Sealer, remains under-researched.

Sealer adhesion plays a crucial role in the long-term success of root canal treatments. After disinfecting the root canal system, it is essential to fill the canal with a sealer and core material (like gutta-percha) to ensure a stable, bacteria-proof seal. Any failure in this seal, whether from bacterial invasion or poor adhesion, can lead to re-infection, treatment failure, and the need for retreatment.^{14,15} AH Plus BC Sealer, a tricalcium silicate cement-based sealer, is known for its biocompatibility and good sealing properties, but its ability to bond effectively with root dentin is influenced by conditions in the canal before sealing.^{8,9}

Intracanal medicaments like calcium hydroxide (CH) or antibiotic pastes (TAP) can affect the bond strength of the sealer to dentin. Bond strength, determined through push-out tests, measures how much force is needed to dislodge the sealer. A strong bond reduces the risk of sealer failure and prevents gaps that could allow bacteria to re-enter.^{7,10} There are no studies examining the impact of amoxicillin-containing triple antibiotic paste on the push-out bond strength of sealer adhesion. This study focused on comparing the effects of CH and amoxicillin-containing TAP on the push-out bond strength of AH Plus BC Sealer. The null hypothesis stated there would be no significant difference in bond strength between the two groups. However, the results showed that amoxicillin-containing TAP significantly improved the bond strength of the sealer compared to CH, suggesting that TAP may enhance sealer adhesion in ways CH does not.

The differing responses to amoxicillin-containing TAP and calcium hydroxide (CH) may stem from their ability to be removed after treatment and their interactions with the dentin. Amoxicillin-containing TAP, due to its chemical properties, tends to diffuse more deeply into dentinal tubules and is more effectively retained within the canal system compared to CH. TAP has a high retention rate, with over 80% of the paste remaining in the dentinal tubules even after irrigation. This characteristic likely creates a more

stable and consistent environment for the sealer to bond, especially in hard-to-reach areas like the apical third of the root canal.^{13,16}

The enhancement of bond strength following the application of TAP can be attributed to its potent demineralizing and erosive effects on radicular dentin, which result from its low pH value. This erosion increases the surface area available for adhesion, potentially improving the bond between sealers and dentin. To further understand this phenomenon, additional studies are necessary to examine the changes in dentin topography after TAP application. Moreover, a decrease in the phosphate/amide I ratio has been observed after treating dentin with TAP, which could also contribute to the improved bond strength of sealers to dentin. Further research is needed to confirm these hypotheses.¹¹

The apical portion of the root canal, where amoxicillin containing TAP demonstrated superior bond strength, is especially difficult to disinfect and seal effectively. This area often contains secondary dentin, accessory canals, and regions of resorption or repaired resorption, all of which can create irregular bonding surfaces. TAP's high retention in these challenging anatomical features may help explain its enhanced bond strength, as it provides a more stable environment for the sealer to adhere to.⁴

Calcium hydroxide (CH) has been widely used for root canal disinfection. Studies have shown that it can improve bond strength.^{2,4} Carvalho et al. found that CH improves bond strength when used for 14 days, followed by proper rinsing with NaOCl and EDTA.¹⁷

The variation in results may stem from the duration of CH exposure, as prolonged use could alter the dentin surface, making it softer and potentially interfering with bonding. In this study, we followed an optimal CH protocol (21 days with NaOCl/EDTA rinse), which minimized adverse effects on sealer adhesion. As anticipated, CH did not reduce the bond strength of AH Plus BC Sealer, aligning with some studies but differing from those

showing weaker bond strength with extended CH use.^{2,18,19}

This study's findings align with other research on the impact of intracanal medicaments on root canal sealer bond strength. Ustun et al. found that propolis, a natural substance with antimicrobial properties, improved bond strength at the apical third of the root more than CH and control groups. This suggests that natural substances like propolis could offer benefits similar to TAP in enhancing bond strength.^{20,21}

Akçay et al. observed that TAP, containing metronidazole, ciprofloxacin, and minocycline, improved the bond strength of epoxy resin-based sealers, particularly in the middle and apical thirds of the root canal.⁴ This supports our findings, where Amoxicillin containing TAP treatment resulted in a two-fold increase in bond strength compared to CH. These studies highlight that TAP, especially in combination with other antibiotics, not only offers strong antimicrobial activity but may also positively influence the bond strength of calcium silicate -based sealers.

While TAP is effective in improving bond strength and eliminating bacteria, it presents challenges, especially in its removal from the canal system. While this high retention is beneficial for long-term antimicrobial action, it raises concerns about residual medicament in the canal.¹⁶

The long-term effects of residual amoxicillin containing TAP, particularly its potential to contribute to antibiotic resistance, are important issues.^{2,4} Additionally, the cytotoxicity of TAP and other intracanal medicaments could impact periapical tissues and healing.²² As a result, further research is needed to determine the optimal concentration, application time, and removal protocols for TAP to maximize its benefits while minimizing potential risks.

CONCLUSION

The findings of this study show that calcium hydroxide (CH) treatment did not significantly affect the bond strength of AH

Plus BC sealer. In contrast, the use of amoxicillin-containing triple antibiotic paste (TAP) resulted in a marked improvement in bond strength, especially in the middle and apical thirds of the root canal. These results imply that while CH does not appear to impact the adhesive properties of the sealer, TAP with amoxicillin may enhance bonding in certain regions of the root canal, potentially influencing the success of the treatment.

Declaration by Authors

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