Effect of intracanal calcium hydroxide dressing on the push out bond strength of AH Plus, MTA Fillapex®, and endosequence BC sealer

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ABSTRACT
Aim: This study aimed to compare the effect of intracanal calcium hydroxide dressing on the push-out bond strength of AH Plus, mineral trioxide aggregate (MTA) Fillapex®, and endosequence BC sealer.

Methodology: Sixty single-rooted human mandibular premolars were decoronated and subjected to biomechanical preparation with the help of a ProTaper rotary file up to size F2. Half of the samples worked as control and the other half that worked as experimental group was treated with calcium hydroxide intracanal medicament. All the samples were divided into three groups (n = 20), according to the sealer used. The samples were obturated using endosequence BC sealer, AH Plus, and MTA Fillapex. Each sample was sectioned horizontally into three parts: cervical, middle, and apical. The sample so prepared was subjected to universal testing machine for the evaluation of the push-out bond strength of the sealers.

Results: Endosequence BC sealer showed the best results, followed by AH Plus sealer and MTA Fillapex sealer. In addition, the push-out bond strength decreased significantly after the use of intracanal calcium hydroxide medicament (ApexCal). Push-out bond strength also decreased from cervical to middle followed by apical third.

Conclusion: Calcium hydroxide intracanal medicament dressing reduced the push out bond strength of all the three sealers used in the study.

Keywords: AH Plus, ApexCal, endosequence BC, MTA Fillapex, push-out bond strength

INTRODUCTION

The first step toward the elimination of infection from root canal is chemico-mechanical preparation. However, it only limits but does not totally prevents the regrowth of endodontic bacteria. Therefore, the use of intracanal medicaments has been advocated to further reduce the number of microorganisms. [1]

Calcium hydroxide is the most popular intracanal medicament due to its well documented antibacterial activity against most of the endodontic pathogens. Most bacteria are unable to survive the highly alkaline environment provided by calcium hydroxide. [2]

The obturation of the root canal system usually requires a core material along with a sealer. The latter should be dimensionally stable, radiopaque, in-soluble and should adhere firmly to both dentin and core filling materials. [3] Therefore, resins have been introduced with the specific focus on obtaining what is called a “monoblock”, which is a single cohesive unit of core material, sealer and root canal dentine. [4]

The first root canal sealer utilizing adhesive technology is epoxy resin-based sealer, AH Plus. These hydrophobic sealers...
are used without any dentine surface treatment or dentine adhesive and are capable of reacting with exposed amino groups in collagen to form covalent bonds.\cite{5}

Endosequence BC sealer (Brasseler, Savannah, GA, USA) is a recently introduced bioceramic sealer based on calcium silicate composition. It is available as premixed, injectable paste containing water-free thickening vehicles and has an excellent flow ability and dimensional stability.\cite{6,7}

Mineral trioxide aggregate (MTA)-based sealers have been introduced in order to achieve biologic properties and a proper seal with MTA. One of these sealers is MTA Fillapex (Angelus, Londrina, Brazil) which is presented in the form of two pastes.\cite{8}

No previous studies have compared the effect of intracanal calcium hydroxide on the push-out bond strength of these sealers. Therefore, the following study was formulated to compare the effect of intracanal calcium hydroxide dressing on the push-out bond strength of AH Plus, MTA Fillapex®, and endosequence BC sealer, and the null hypothesis tested was that the intracanal dressing of calcium hydroxide has no effect on the push-out bond strength of AH Plus, MTA Fillapex, and endosequence BC sealers, and there was no difference in the push-out bond strength of sealer tested.

Clinical significance
The bonding of root canal sealer to the dentine is paramount in maintaining the integrity of the seal in a root canal filling. When the dentinal tubules are occluded by either a smear layer or intracanal calcium hydroxide dressing residues, endodontic sealers will be prevented from penetrating the tubules (preventing tag formation), hence affecting their bond strength.

METHODOLOGY

Selection of samples
Sixty human permanent single-rooted mandibular premolars (selected on the basis of a previous pilot study using G*Power software, Franz Faul, Universität Kiel, Germany) with relatively straight roots and fully formed apices, freshly prepared (confirmed by radiovisiography both labiolingually and mesiodistally), no visible root caries, and no fracture or cracks on examination under microscope (×10).

The external surfaces of the teeth were cleaned with an ultrasonic scaler and stored in a 5% chloramine-T solution until the time of study.

Sample preparation
Access cavities were prepared by using Endo-access bur (Dentsply Maillefer, Ballaigues, Switzerland) in a high-speed hand-piece with water spray; the canals were localized and explored with a size #15-K type file (Dentsply Maillefer, Ballaigues, Switzerland) to the apex. The teeth were then decoronated with a low-speed hand-piece and diamond discs to obtain a standardized length of 16 mm for all the roots.

A working length of 15 mm was determined, and the root canals were shaped with ProTaper rotary files (Dentsply Tulsa Dental, Tulsa, OK, USA), up to size F2. The canals were first irrigated with 5 mL of 2.5% NaOCl for 60 s followed by 5 mL of freshly prepared 17% ethylenediaminetetraacetic acid (EDTA) for 60 s, and, finally, with 10 mL of distilled water.

The specimens were then divided into three groups on the basis of sealers used for obturation, as Groups I, II, and III, i.e., AH Plus, MTA Fillapex, and endosequence BC sealers, respectively.

Each group was further divided into two subgroups on the basis of the use of the intracanal dressing of calcium hydroxide. Subgroup A (n = 10) used intracanal calcium hydroxide dressing (ApexCal) for 1 week. After 1 week, in subgroup A, manual agitation with the master apical file was done in conjunction with 10-ml 2.5% NaOCl and 10-ml 17% EDTA for removal of intracanal dressing as it is the most common method of medicament removal. Subgroup B (n = 10) did not use any intracanal dressing.

All the specimens were dried using paper points and obturated using the cold lateral compaction technique.

The criteria for teeth selected include a single root canal (confirmed by radiography both labiolingually and mesiodistally), no visible root caries, and no fracture or cracks on examination under microscope (×10).

Table 1: Mean push-out bond strength values and standard deviation (in MPa) for tested sealers at different root thirds, with or without prior application of calcium hydroxide intracanal dressing (P<0.05—significant)

|                      | Cervical third | Middle third | Apical third |
|----------------------|----------------|--------------|--------------|
|                      | Without intracanal medicament | With calcium hydroxide intracanal medicament | Without intracanal medicament | With calcium hydroxide intracanal medicament | Without intracanal medicament | With calcium hydroxide intracanal medicament |
| Group I              | 6.56 ± 1.15    | 4.53 ± 0.31  | 4.18 ± 0.96  | 2.67 ± 0.26  | 2.66 ± 0.95  | 1.60 ± 0.51   |
| Group II             | 4.03 ± 0.50    | 2.64 ± 0.27  | 3.40 ± 0.42  | 1.67 ± 0.25  | 1.75 ± 0.26  | 0.80 ± 0.13   |
| Group III            | 9.12 ± 0.70    | 6.65 ± 0.27  | 6.91 ± 0.65  | 3.63 ± 0.28  | 5.15 ± 0.66  | 2.59 ± 0.26   |

Group I: AH Plus; Group II: MTA Fillapex; Group III: Endosequence BC sealer; SD: Standard deviation
with size F2 ProTaper gutta-percha points and AH Plus sealer (Group I), MTA Fillapex (Group II), and endosequence BC sealer (Group III). The sealer application was done using a lentulo spiral. Excess gutta-percha was removed using a heated plunger.

**Push-out bond strength test**
The prepared roots were placed in 100% relative humidity at 37°C for 24 h before testing.

The specimens were transversally sectioned into four slices of 1 mm each. The first coronal slice (corresponding to cervical) was discarded, and the rest, i.e., cervical, middle, and apical thirds were used for push-out test. The thickness of each root section was verified with a digital caliper.

The push-out bond strength was evaluated using the universal testing machine. Loading was applied on the root filling material by using a 1, 0.5, and 0.3 mm-diameter (for cervical, middle, and apical, respectively) custom stainless steel cylindrical plunger mounted on a Lloyd LRX universal testing machine (Lloyd Instruments Ltd, Fareham, UK). The push-out force was applied at a crosshead speed of 1 mm/min in a coronal-to-apical direction until bond failure occurred. The push-out bond strength at failure was calculated in Megapascals (Mpa) by dividing the force by the surface area of the test material.

The area in each section was calculated by using the following formula:

\[ \text{Area} = 2 \pi r \times h \]

where \( \pi = \text{constant value of 3.14} \),
\( r = \text{radius of the intraradicular space (root canal radius)}, \) and
\( h = \text{height (thickness of the root dentin slice) in mm} \).

**Statistical analysis**
One-way ANOVA test was applied to find the mean of push-out bond strength in Groups I, II, and III, and *post hoc* Bonferroni test was applied to find the significance among all the thirds. \( P < 0.05 \) was considered statistically significant.

**RESULTS**
On applying one-way ANOVA test, for intergroup comparison, we found that the mean push-out bond strength in subgroups IA, IIA, and IIIA was significantly higher than that of subgroups IB, IIB, and IIB. This proved to be true at all thirds, i.e., cervical, middle, and apical thirds [Table 1]. Then, on applying *post hoc* Bonferroni test, for intragroup comparison, it was found that the cervical thirds showed statistically significant highest push-out bond strength values followed by the middle and the apical third for all the groups.

The order of push out bond strength values of sealers used in the present study at all levels was as follows Group III > Group I > Group II.

The difference in the mean push-out bond strength of the sealers was statistically significant between each group, at each level, and between different levels within each group \( (P < 0.05) \). Hence, both the null hypotheses were rejected.

**DISCUSSION**
Bonding of endodontic sealer to intraradicular dentin is advantageous in maintaining the integrity of the sealer–dentin interface during various mechanical stresses. [9]

Despite the advances in instrumentation techniques and irrigation chemicals and devices, intracanal medication is recommended to improve disinfection and block coronal leakage. [10] Thus, calcium hydroxide was used in our study, which is the most widely used and investigated intracanal medicament because of its antibacterial and biological properties. [11]

From the results of our study, it was found that statistically significant highest bond strength was exhibited by endosequence BC sealer (Brasseler, Savannah, GA, USA) in the both subgroups A and B when compared to AH Plus and MTA Fillapex sealer. This may be due to its true self-adhesive nature, which forms a chemical bond, due to the formation of hydroxyapatite hybrid layer. [12] This hybrid layer is formed on the release of calcium and hydroxyl ions from the calcium silicate-containing material when it comes in contact with phosphate-containing fluids. Therefore, the formation of this interfacial layer develops a chemical bond between the sealer and dentinal walls. [13] Moreover, it is hydrophilic and possesses low contact angle together with smaller particle size, allowing it to spread easily over the canal walls, resulting in deep penetration into the tubules for mechanical interlocking and therefore superior adhesion, providing adaptation and good hermetic seal. [14]

Similar findings were reported by Elbatouty *et al.* [15] and Madhuri *et al.* [16] stating the highest mean push out bond strength value for endosequence BC sealer when compared to sealers used in their respective studies.
AH plus sealer showed superior push-out bond strength when compared to MTA Fillapex. This might be due to the fact that the AH Plus resin sealer penetrates deeper into the dentinal tubules due to its flowability, long-term polymerization time, very low shrinkage, long-term dimensional stability, and its ability to react with any exposed amino groups in collagen to form covalent bonds between the resin and collagen upon opening of the epoxide ring.\(^{17}\)

Similar findings were reported by Gurgel Filho et al.\(^{18}\) and Guiotti et al.,\(^{19}\) who also reported that AH Plus sealer has significantly higher push out bond strength as compared to MTA Fillapex.

The least bond strength among all the three groups was demonstrated by MTA Fillapex, which could be due to the presence of resin components in MTA fillapex structure and decreased adhesion of tag like structures. Polineni et al.\(^{19}\) reported that inferior marginal adaptation of MTA Fillapex, could be due to low adhesion of the material due to poor micro tag formation on setting while Forough Reyhani et al.\(^{20}\) demonstrated low push out bond strength of MTA Fillapex as compared to epiphany, due to the lower adhesion capacity of the tag like structures.

Intragroup comparison revealed decrease in the push-out bond strength in all the groups where ApexCal (intracanal calcium hydroxide dressing) was used, because its residue may have acted as a physical barrier between root dentin and the endodontic sealers as only manual agitation with master apical file was used for removal of intracanal dressing. Findings similar to the present study has been demonstrated by Ghabraei et al.\(^{21}\) and Guiotti et al.,\(^{19}\) who also reported that the bond strength of root canal sealer to dentin decreased after application of intra-canal dressing of calcium hydroxide. Findings contrary to the present study was reported by Amin et al.\(^{10}\) and Akcay et al.,\(^{1}\) who reported that intracanal calcium hydroxide dressing did not decrease the push out bond strength of root canal sealer.

In the present study, intra subgroup comparison in all the groups showed that bond strength decreases from cervical to apical because of the reduction in the density of the dentin tubules from cervical to apical third, with the apical third being the least favorable to hybridization, with areas without dentin tubules and irregular dentin.\(^{22}\)

Another reason for low push-out bond strength in the apical region may be the presence of less divergent dentinal tubules toward the apical portion and formation of open spaces due to the difficulty of evenly distributing sealer.\(^{23}\) This might happen because irrigants do not reach the apical portion, which results in incomplete removal of debris, leading to the presence of a smear layer preventing the sealers to penetrate in the dentinal tubules.\(^{24}\) This finding is in accordance with those of Helvacıoğlu Kıvanç et al.\(^{25}\) and Rached Júnior et al.\(^{26}\) who reported minimal bond strength at apical region because the root thirds differ structurally with canal geometry and collagen/mineral content.

**CONCLUSION**

Prior application of a calcium hydroxide dressing only had a negative effect on the push-out bond strength of the AH Plus sealer, MTA Fillapex, and endosequence BC. Hence, further studies are required to investigate the effect of different removal techniques of intracanal medicaments on the bond strength of AH Plus, MTA Fillapex, and endosequence BC sealers.

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**Conflicts of interest**

There are no conflicts of interest.

**REFERENCES**

1. Akcay M, Arslan H, Topcuoglu HS, Tuncay O. Effect of Calcium Hydroxide and Double and Triple Antibiotic Pastes on the Bond Strength of Epoxy Resin-based Sealer to Root Canal Dentin. J Endod 2014;40:1663-7.
2. Siqueira JF Jr., Lopes HP. Mechanisms of antimicrobial activity of calcium hydroxide: A critical review. Int Endod J 1999;32:361-9.
3. Saleh IM, Ruyter IE, Haapasalo MP, Orstavik D. Adhesion of endodontic sealers: Scanning electron microscopy and energy dispersive spectroscopy. J Endod 2003;29:595e601.
4. Fisher MA, Berzins DW, Bahcall JK. An in vitro comparison of bond strength of various obturation materials to root canal dentin using a push-out test design. J Endod 2007;33:856e8.
5. Darrag AM, Fayyad, Dalia. Adhesives in endodontics. Part II. ENDOD. 2011; 5. 87-105.
6. DeLong C, He J, Woodmansey KF. The effect of obturation technique on the push-out bond strength of calcium silicate sealers. J Endod. 2015;41:385-8.
7. Shokouhinejad N, Hoseini A, Gorjestani H, Shamshiri AR. The effect of different irrigation protocols for smear layer removal on bond strength of a new bio ceramic sealer. Iran Endod J 2013;8:10-3.
8. Gurgel-Filho FD, Leite FM, Benício de Lima J, Montenegro JP, Saavedra F, Silva EJ. Comparative evaluation of push-out bond strength of a MTA-based root canal sealer. Braz. J. Oral Sci 2014;13:114-7.
9. Shokouhinejad N, Hoseini A, Gorjestani H, Shamshiri AR. The effect of different irrigation protocols for smear layer removal on bond strength of a new bio ceramic sealer. Iran Endod J 2013;8:10-3.
10. Amin SAW, Seyam RS and El-Samman MA. The Effect of Prior Calcium Hydroxide Intracanal Placement on the Bond Strength of Two Calcium Silicate–based and an Epoxy Resin–based Endodontic Sealer. J Endod. 2012;38:696-9.
11. Mohammadi Z, Dummer PM. Properties and applications of calcium hydroxide in endodontics and dental traumatology. Int Endod J 2011;44:697-730.
12. Koch K, Brave D. Bioceramic Technology- the game changer in endodontics. ENDO 2009;2:17-21.
13. Sarkar NK, Caicedo R, Ritwik P, Moiseyeva R, Kawashima I. Physicochemical Basis of the Biologic Properties of Mineral Trioxide Aggregate. J Endod 2005;31:97-100.
14. Bird DC, Komabayashi T, Guo L, Opperman LA, Spears R. In vitro evaluation of dentinal tubule penetration and biomineralization ability of a new root-end filling material. J Endod 2012;38:1093-6.
15. Elbatouty KM, Ibrahim DY, Youniss WN. In vitro bond strength of bioceramic root canal sealer in comparison to resin-based and eugenol-based root canal sealers. Endo (LondEngl) 2015;9:59-63.
16. Madhuri GV, Varri S, Bolla N, Mandava P, Akkala LS, Shaik J. Comparison of bond strength of different endodontic sealers to root dentin: An in vitro push-out test. J Conserv Dent 2016;19:461-4.
17. Tagger M, Tagger E, Tjan AH, Bakland LK. Measurement of adhesion of endodontic sealers to dentin. J Endod 2002;28:351-4.
18. Guiotti FA, Kuga MC, Duarte MA, Sant'Anna AJ, Faria G. Effect of calcium hydroxide dressing on push-out bond strength of endodontic sealers to root canal dentin. Braz Oral Res. 2014;28.
19. Polineni S, Bolla N, Mandava P, Vemuri S, Mallela M. Marginal adaptation of newer root canal sealers to dentin: A SEM study. J Conserv Dent 2016;19:360-3.
20. Forough Reyhani M, Ghasemi N, Rahimi S, Salem Milani A, Mokhtari H, Shokouz S, et al. Push-Out Bond Strength of Dorifill, Epiphany and MTA-Fillapex Sealers to Root Canal Dentin with and without Smear Layer. Iran Endod J 2014;9:246-50.
21. Ghahreai S, Bolhari B, Yaghoobnejad F, Meraji N. Effect of Intra-Canal Calcium Hydroxide Remnants on the Push-Out Bond Strength of Two Endodontic Sealers. Iran Endod J 2017;12:168-72.
22. Guneser MB, Akbulut MB, Eldeniz AU. Effect of various endodontic irrigants on the push out bond strength of biodentine and conventional root perforation repair materials. J Endod 2013;39:380-4.
23. Ustun Y, Arslan S, Aslan T. Effects of calcium hydroxide and propolis intracanal medicaments on bond strength of resin-based endodontic sealer as assessed by push-out test. Dent Mater J 2013;32:913-9.
24. EL-Ma’aita AM, Qualtrougha AJE, Watts DC. The effect of smear layer on the push-out bond strength of root canal calcium silicate cements. Dent Mater 2013;29:797-803.
25. Helvacıoğlu Kıvanç B, Deniz Arsu H, Uçtaşlı MB, Okay TC. The effect of different adhesive system applications on push out bond strengths of glass fiber posts. J Adv Prosthodont 2013;5:305-11.
26. Rached-Júnior FJ, Souza AM, Macedo LM, Raucci-Neto W, Baratto-Filho F, Silva BM, et al. Effect of root canal filling techniques on the bond strength of epoxy resin-based sealers. Braz Oral Res [online]. 2016;30:e24.