EFFECTS OF MTAD ON THE BOND STRENGTH OF BIOCERAMIC ROOT CANAL SEALER

Ayşin Dumani[1], Cemre Sapmaz Uçan[1], Ayfer Atav Ateş[2], Şehnaz Yılmaz[1], Oğuz Yoldaş[1]

1 Department of Endodontics, Cukurova University, Turkey
2 Department of Endodontics, Istanbul Okan University, Turkey

CORRESPONDING AUTHOR: carminaayfer@hotmail.com

ABSTRACT

Aim: The aim of this in-vitro study was to investigate the effects of MTAD (a mixture of doxycycline, citric acid, and a detergent) on the bond strength of AH Plus (Dentsply DeTrey GmbH, Konstanz, Germany) and EndoSequence BC sealer (Brasseler USA, Savannah, Georgia, USA).

Materials & Methods: Eighty-four decoronated single-rooted human incisor teeth were prepared with Reciproc R25 files (VDW, Munich, Germany), and the canal was irrigated with 5 mL 1.3% NaOCl. The roots were randomly assigned to four groups (n = 21), according to the final irrigation protocol and sealer selection: Group 1: distilled water-AH Plus; Group 2: distilled water-EndoSequence BC; Group 3: MTAD-AH Plus; Group 4: MTAD-EndoSequence BC. For the final flush, in Groups 1 and 2, the root canals were irrigated with 5mL of distilled water; in Groups 3 and 4, 5mL of MTAD was used for 1 minute. After root canal obturation, specimens was embedded in an acrylic block and sectioned horizontally at three levels (coronal, middle, apical). Bond strength of sealer to root canal dentin was assessed via push-out test using a universal testing machine.

Results: There were no significant differences among the groups in coronal and apical thirds. In the middle root third, Group 4 showed significantly lower push-out bond strength values than Group 2 (p=0.023). No significant difference was found between the two root canal sealers.

Conclusions: Overall, MTAD final irrigation caused lower push-out bond strenght values than distilled water with no significancy.

PALAVRAS-CHAVE: MTAD, Endodontics, Root canal sealers.
http://dx.doi.org/10.19177/jrd.v7e3201953-58

INTRODUCTION

Instrumentation of the root canals causes a smear layer on the dentinal walls, and there is some controversy in the literature as to whether this layer should be retained or removed. Some researchers believe that this layer may preserve the bacteria within the dentinal tubules and also serve as a source of nutrients for some species of intracanal microbiota.[1] This layer prevents disinfection of dentinal tubules and acts as a block barrier between obturating materials and the canal wall, thus interfering with the formation of an adequate seal.[2] Therefore, numerous irrigation solutions have been recommended for the removal of this layer.[3,4]

Several researchers have suggested the consecutive use of organic and inorganic solvents as endodontic irrigants, since no one solution has yet demonstrated removal of the smear layer.[4] The alternating use of ethylenediamine tetraacetic acid (EDTA) and sodium hypochlorite (NaOCl) has long been effective in removing the endodontic smear layer.[5] However, prolonged application of EDTA (>1min) may cause unintended erosion of the peritubular dentine, and it also has demonstrated limited antibacterial activity.[6] Recently, another endodontic irrigant containing 3% doxycycline hyclate, 4.25% citric acid, and 0.5% polysorbate 80 detergent has been introduced as MTAD. This irrigation solution has low surface tension due to the addition of detergent and is recommended as a final rinse after initial irrigation with 1.3% NaOCl to remove the mineral part of the smear layer and disinfect the root canal space.[7]

MTAD was reported as a clinically effective, biocompatible endodontic irrigant with efficient antibacterial activity.[8,9] Previous in vitro studies have shown that E.faecalis is highly susceptible to MTAD even when diluted with this solution 200, whereas NaOCl loses its antibacterial activity beyond a dilution of 32 against the same isolate.[10]

Previous in vitro studies have shown that E.faecalis is highly susceptible to MTAD even when diluted with this solution 200, whereas NaOCl loses its antibacterial activity beyond a dilution of 32 against the same isolate. MTAD has a solubilizing impact on dentin and pulp tissue similar to **EDTA.**[8] However, chemical irrigants may change the dentin surface composition, possibly causing some alterations between the interaction with dentin and root canal filling materials.[11]

Many studies have assessed the effect of endodontic irrigants on the bond strength of different types of root canal sealers to dentin.[12,13] EndoSequence BC Sealer (Brasseler, Savannah, USA), also known as iRoot SP (Innovative Bioceramix, Vancouver, BC, Canada), has gained popularity in recent years. This sealer is composed of tricalcium silicate, dicalcium silicate, calcium phosphate monobasic, calcium hydroxide, zirconium oxide and also injectable. Bioceramic materials have antimicrobial activity, biocompatibility, great physical properties and also ability to produce hydroxyapatite, which affords a direct bond between dentin and the material. [14,16]

The bond strength of iRoot SP to radicular dentin has been reported to be equial to AH Plus (Dentsply DeTrey GmbH, Konstanz, Germany) which was used as the control material in endodontic research due to its low solubility, long-lasting dimensional stability, and adequate micro-retention to dentin.[17] To our knowledge, no study has examined the effect of MTAD on the bond strength of EndoSequence BC sealer to root canal dentin. The aim of this study is to evaluate the push-out bond strength of EndoSequence BC sealer to root canal dentin with a final irrigation of MTAD compared to distilled water.

MATERIALS & METHODS

This study was approved by the Institutional Review Board of the University of Cukurova. Eighty-four single-rooted human incisor teeth, extracted for periodontal problems, were selected for this study. Each tooth was decoronated with water-cooled diamond-coated bur, and the roots were adjusted to a standardized 16 mm length. The working length of root canals was adjusted to 15 mm. Root canal shaping procedures were performed using Reciproc R25 files (VDW, Munich, Germany), and the canal was irrigated with 5 mL 1.3% NaOCl. The roots were randomly assigned to four groups (n = 21) according to the final irrigation protocol and sealer selection: Group 1: distilled water-AH Plus; Group 2: distilled water-EndoSequence BC; Group 3: MTAD-AH Plus; and Group 4: MTAD-EndoSequence BC. For the final flush, in Groups 1 and 2, the root canals were irrigated with 5mL of distilled water; in Groups 3 and 4, 5 mL of MTAD was used for 1 minute. Then root canals were obturated with gutta-percha and AH Plus or EndoSequence BC sealer using the cold lateral compaction technique, and the access cavity was sealed with Cavit. The specimens were placed in 100% humidity for 7 days at 37°C to ensure complete setting of the sealers.

PUSH-OUT TEST

After the 7-day storage period, each specimen was embedded in an acrylic block and sectioned horizontally (1-mm thickness) at three levels (coronal, middle and apical) with a low-speed saw (EXAKT 300 CL; Exakt Apparatbau, Norderstedt, Germany), with continuous water irrigation to prevent overheating. Sixty-three dentin slices from each group were subjected to push-out tests using a universal testing machine (Testometric Company Ltd., Rochdale, Lancashire, England) with a crosshead speed of 1 mm/minute. The bar's tip presented 0.8, and 1 mm (diameter) cylindrical pluggers, matching the diameter of each canal third. The diameter of the pluggers was at least 80% of the diameter of each canal third. Data were measured in Newtons (N) and the bond strength, in megapascals (MPa), was calculated by dividing the force by the area.[13] Slice thickness was measured with calipers, and bonding surface area was calculated using the formula for a conical frustum: area = $\pi(r2 + r1)(h2 + [r2 - r1]2)0.5$, where r1 is the apical radius of the canal diameter (in mm), r2 is the coronal radius, h is the thickness of the root section (in mm), and π is a constant. After the push-out test, each specimen was examined under a stereomicroscope (SZ61; Olympus, Tokyo, Japan) at 40× magnification to determine the failure mode. Failure was categorized as adhesive failure at the sealer-dentin interface, cohesive failure within sealer, or mixed failure).

STATISTICAL ANALYSIS

Data were analyzed using two-way analysis of the variance and Tukey's post hoc tests (p=0.05). All analyses were performed using IBM SPSS Statistics Version 20.0 statistical software package. Variables were summarized using mean and standard deviation. Since the data were obtained from a factorial design with two factors at two levels each, two-way analysis of variance analysis (with Tukey's post hoc procedure) was used for comparison. The statistical level of significance was set at p=0.05 for all tests.

RESULTS

The mean values (in MPa) of push-out bond strength of root canal sealers for each group and pairwise comparisons of groups are shown in Figure 1 and 2, respectively. There were no significant differences between the groups in coronal and apical thirds. In the middle root third, Group 4 showed significantly lower push-out bond strength values than Group 2 (p=0.023). No significant difference was found between the two root canal sealers. The majority of specimens had cohesive failures.

DISCUSSION

Smear layer removal from the dentin surface by employing different irrigation protocols can change dentin surface permeability and solubility due to changes in the chemical and constitutional composition of human

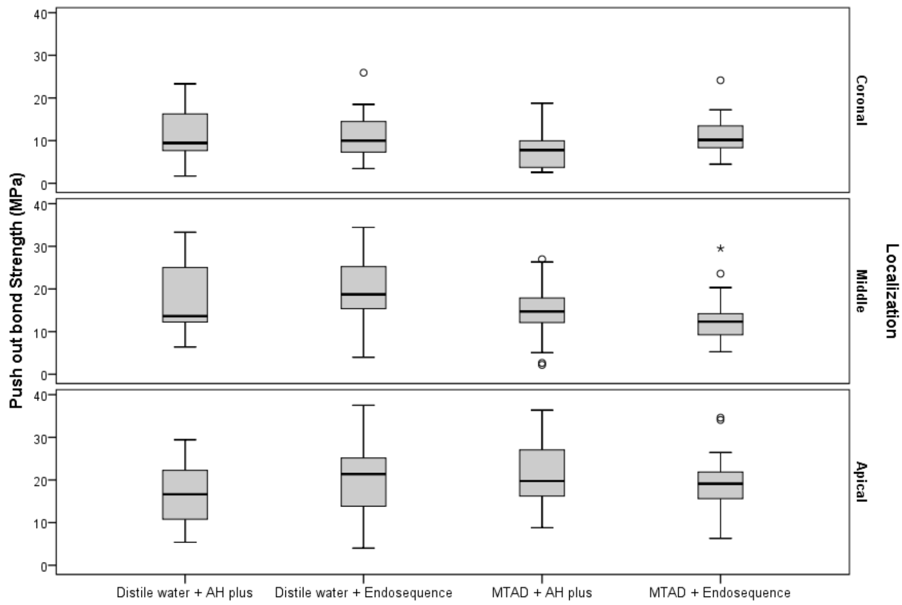

Figure 1: Push-out bond strenght of root canal sealers according to localization

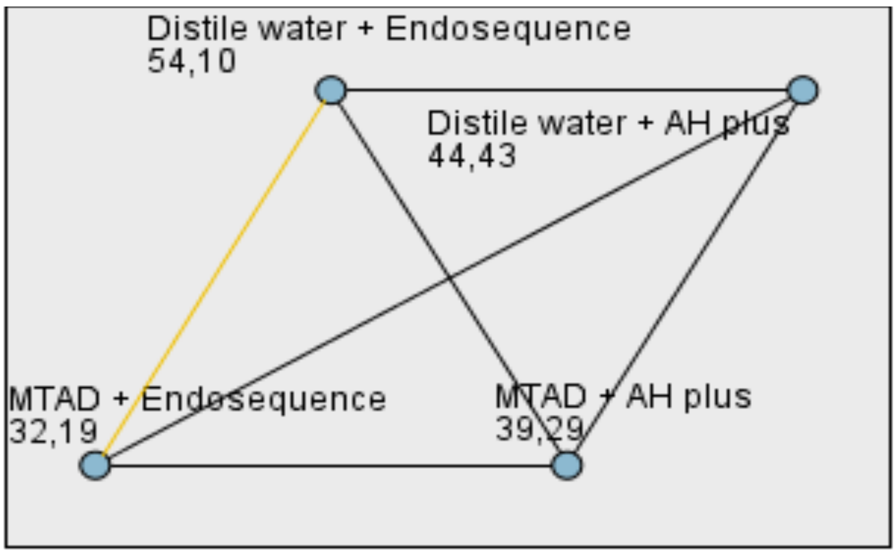

Figure 2: Pairwise comparisions of groups

dentin, which in turn effects the adhesion of materials to the dentin surface.[11,18,19] Close contact between the adhesive material and the substrate is required to achieve proper adhesion, which is essential both for enabling either chemical adhesion or penetration towards the micromechanical surface interlocking and for providing molecular attraction. Micromechanical retention or frictional strength of an sealer from intraradicular dentin with high bond strength is beneficial in sustaining the entirety of the sealer–dentin interface.[20,21] This is necessary for establishing a fluid-tight seal and for supplying resistance for dislocation of the root filling during tooth flexure and dental procedures.[21,22]

Several studies have shown that MTAD and EDTA have the same efficacy for smear layer removal, but EDTA has no antimicrobial effect.[23,24] Torabinejad et al.[7] demonstrated that total removal of the smear layer was obtained in the majority of the specimens when irrigation with 1.3% of NaOCl was followed by MTAD. Both doxycycline and citric acid have been individually reported as being able to remove smear layer. Based on the findings of that study, we used a similar irrigation protocol in this research, and also noting that Mortazavi et al.[25] demonstrated that a clinical protocol of MTAD (1.3% NaOCl as a root canal irrigant and a 5-minute application of the agent as a final rinse) had no unfavourable effect on the shear bond strength of self-etch adhesives to dentin.

However, Ertas & Bagsen[26] showed that MTAD significantly reduced the bond strength of AH Plus to the root canal dentin, as compared with the groups irrigated with 1% NaOCl, 17% EDTA and 1% NaOCl, 2% CHX, and saline. In accordance with this study, Hashem et al. [13] reported that the use of MTAD as a final irrigant with gutta-percha/AH Plus resulted in a significant decrease in its bond strength, as compared with EDTA/AH Plus. Sayin et al.[27] reported that the reason for inefficient removal of the smear layer is the low decalcifying effect of MTAD, which is the consequent cause of reduction.

Beltz et al.[28] demonstrated the solubilizing effects of irrigating solutions on dentin tissue. The authors suggested an increased mass of dentin when irrigated with MTAD, while a reduced mass of dentin when irrigated with saline, NaOCl and EDTA. They resulted that MTAD cumulates on dentin tissue. Likewise, Tay et al.[24] reported that the demineralized dentin zone generated by MTAD is thicker, around 10–12 mm, compared to EDTA, which is 4–6 mm thick. Moreover, the MTAD constituent Tween 20 (a detergent) increased dentin surface energy and wet ability leading to increased intertubular dentin permeability. This process lowered the binding efficacy of the hydrophobic AH Plus sealer due to increased collagen matrix and intertubular fluid exposure.

Consistent with these studies, the current research showed that MTAD reduced the bond strength of AH Plus and EndoSequence BC sealer to root canal dentin in all localizations when compared with distilled water, but the reduction was not statistically significant. Only in the middle root third, MTAD resulted in significantly lower push-out bond strength values than distilled water when EndoSequence BC sealer was used.

The push-out test is an influential technique to assess the bond strength of root canal filling materials to root dentin with great reliability. This method lets researchers to value root canal sealers even with low bond strength and to determine coronal–middle–apical differences. It is simple to examine the bond strength with the push-out test method than with shearing test methods, because it causes fractures parallel to the dentin–sealer interface.[29] Due to its reliability, this method was used in the present study.

Adhesion is one of the most desirable characteristics of root canal cement, which is an essential aspect of a filling material, along with other physical properties. Ideal endodontic cement is expected bonding both the gutta-percha core and the canal wall, thereby isolating the root canal space.[30]

EndoSequence BC Sealer has good sealing ability, uses the moisture present within the dentinal tubules to start and complete the setting reaction and equivalent bond strength to AH Plus, and is higher than Sealapex and EndoREZ[17] In the current study, there was no significant difference in the bond strength of EndoSequence BC and AH Plus when distilled water was used as an irrigant.

To date, numerous irrigation solutions and sealers have been developed to progress the sealing ability and stability of the root canal filling. This is because poorly filled areas of the root canal system can be a source of bacterial growth, as it was reported that 58% of treatment failures were due to inadequate obturation and post-obturation microleakage[31] However, further studies are required to investigate the effect of irrigation solutions on the bond strength of EndoSequence BC sealer.

CONCLUSION

The MTAD-EndoSequence BC group showed significantly lower push-out bond strength values than the distilled water–EndoSequence BC group in the middle root third (p=0.023). Overall, MTAD final irrigation caused lower push-out bond strength values than distilled water but with less than asignificant difference.

CONFLICT OF INTEREST

The authors deny any conflicts of interest related to this study.

REFERENCES

1. Mader CL, Baumgartner JC, Peters DD. Scanning electron microscopic investigation of the smeared layer on root canal walls. Journal of Endodontics 1984;10:477–83.

2. Cergneux M, Ciucchi B, Dietschi JM, Holz J. The influence of the smear layer on the sealing ability of canal obturation. Int Endod J 1987;20:228 –32.

3. Torabinejad M, Cho Y, Khademi AA, Bakland LK, Shabahang S. The effect of various concentrations of sodium hypochlorite on the ability of MTAD to remove the smear layer. J Endod 2003;29(4):233-9.

4. Zehnder M. Root canal irrigants. J Endod 2006;32(5):389-98.

5. Baumgartner JC, Mader CL. A scanning electron microscopic evaluation of four root canal irrigation regimens. J Endod 1987;13:147-57.

6. Calt S, Serper A. Time-dependent effects of EDTA on dentin structures. J Endod 2002;28:17-9.

7. Torabinejad M, Khademi AA, Babagoli J, Cho Y, Johnson WB, Bozhilov K, et al. A new solution for the removal of the smear layer. J Endod 2003;29:170–5.

8. Zhang W, Torabinejad M, Li Y. Evaluation of cytotoxicity of MTAD using the MTT tetrazoluim method. J Endod 2003;29:654–7.

9. Torabinejad M, Shabahang S, Aprecio RM, Kettering JD. The antimicrobial effect of MTAD: an in vitro investigation. J Endod 2003;29:400–3.

10. Shahabang S, Torabinejad M. Effect of MTAD on Enterococcus faecalis-contaminated root canals of extracted human teeth. J Endod 2003;29(9):576-9.

11. Dogan H, Qalt S. Effects of chelating agents and sodium hypochlorite on mineral content of root dentin. J Endod 2001;27(9):578-80.

12. de Assis DF, Prado M, Simao RA. Evaluation of the interaction between endodontic sealers and dentin treated with different irrigant solutions. J Endod 2011;37(11):1550-2.

13. Hashem AA, Ghoneim AG, Lutfy RA, Fouda MY. The effect of different irrigating solutions on bond strength of two root canal-filling systems. J Endod 2009;35(4):537.

14. Nagas E, Cehreli Z, Uyanik MO, Durmaz V. Bond strength of a calcium silicate-based sealer tested in bulk or with different main core materials. Braz Oral Res 2014;28(1):1-7.

15. Zhang W, Li Z, Peng B. Ex vivo cytotoxicity of a new calcium silicate-based canal filling material. Int Endod J 2010;43(9):769-74.

16. Reyes-Carmona JF, Felippe MS, Felippe WT. The biomineralization ability of mineral trioxide aggregate and Portland cement on dentin enhances the push-out strength. J Endod 2010;36:286–91.

17. Ersahan S, Aydin C. Dislocation resistance of iRoot SP, a calcium silicate-based sealer, from radicular dentine. J Endod. 2010 ;36(12):2000-2.

18. Van Meerbeek B, Lambrecht P, Inokoshi S, Braem M, Vanherle G. Factors affecting adhesion to mineralized tissues. Oper Dent 1992;5:111–24.

19. Erickson RL. Surface interactions of dentin adhesive materials. Oper Dent 1992;5: 81–94.

20. Saleh IM, Ruyter IE, Haapasalo MP, Orstavik D. Adhesion of endodontic sealers: scanning electron microscopy and energy dispersive spectroscopy. J Endod 2003;29(9):595-601.

21. Huffman BP, Mai S, Pinna L, Weller RN, Primus CM, Gutmann JL, et al. Dislocation resistance of ProRoot Endo Sealer, a calcium silicate-based root canal sealer, from radicular dentine. Int Endod J 2009;42(1):34-46.

22. Shipper G, Ørstavik D, Teixeira FB, Trope M. An evaluation of microbial leakage in roots filled with a thermoplastic synthetic polymer-based

root canal filling material (Resilon). J Endod 2004;30(5):342-7.

23. Mozayeni MA, Javaheri GH, Poorroosta P, Ashari MA, Javaheri HH. Effect of 17% EDTA and MTAD on intracanal smear layer removal: A scanning electron microscopic study. Aust Endod J 2009;35:13–7.

24. Tay FR, Pashley DH, Loushine RJ, Doyle MD, Gillespie WT, Weller RN, et al. Ultrastructure of smear layer-covered intraradicular dentin after irrigation with BioPure MTAD. J Endod 2006;32:218–21.

25. Mortazavi V, Khademi A, Khosravi K, Fathi M, Ebrahimi-Chaharom M, Shahnaseri S, et al.. Effect of MTAD on the shear bond strength of self-etch adhesives to dentin. Dent Res J 2012;9(1):24–30.

26. Ertas H, Sagsen B. Comparison of the effect of MTAD and conventional irrigation agents on apical leakage and push-out bond strength of root canal filling. Scanning 2015;37(6):393-8.

27. Sayin TC, Cehreli ZC, Deniz D, Akcay A, Tuncel B, Dagli F, et al. Time-dependent decalcifying effects of endodontic irrigants with antibacterial properties. J Endod 2009;35(2):280-3.

28. Beltz RE, Torabinejad M, Pouresmail M. Quantitative analysis of the solubilizing action of MTAD, sodium hypochlorite, and EDTA on bovine pulp and dentin. J Endod 2003;29(5):334-7.

29. Goracci C, Tavares AU, Fabianelli A, Monticelli F, Raffaelli O, Cardoso PC,et al.. The adhesion between fiber posts and root canal walls: comparison between microtensile and push-out bond strength measurements. Eur J Oral Sci 2004;112:353–61.

30. Grossman LI. Physical properties of root canal cements. J Endod 1976;2:166–75.

31. Benenati FW. Obturation of the radicular space. In: Ingle JI, Bakland LK, Baumgartner JC, editors. Ingle's Endodontics. 6 ed. Hamilton: BC Decker; 2008. pp. 1053–1087.