The Effect of Different Irrigating Solutions on Bond Strength of Two Root Canal–filling Systems

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Abstract

The bond strength of ActiV GP root canal filling system and gutta-percha/AH plus sealer when used after final rinse with different irrigation protocols was evaluated in this study. Forty roots were randomly divided into four groups (n = 10) according to the final irrigation regimen: group 1, 5 mL 17% EDTA; group 2, 5 mL 17% EDTA followed by 5 mL 2% chlorhexidine gluconate (CHX); group 3, 5 mL MTAD; and group 4, 5 mL MTAD followed by 5 mL 2% CHX. Each group was further subdivided into two subgroups (n = 5): in subgroup a, the root canals were filled using warm gutta-percha and AH plus sealer, and in subgroup b, the root canals were filled using the ActiV GP obturation system. Two-millimeter thick horizontal sections from the coronal and midthirds of each root were sliced for the push-out bond strength measurement. EDTA/CHX/ActiV GP (2.46 ± 1.02 MPa) yielded significantly the highest mean bond strength value. The significantly lowest bond strength was recorded for EDTA/ActiV GP (1.12 ± 0.72 MPa). It was concluded that the bond strength of ActiV GP was improved by using 2% CHX in the final irrigation after 17% EDTA, whereas CHX did not enhance the effect of MTAD on the bond strength of the material. The bond strength of gutta-percha/AH plus was adversely affected by MTAD and MTAD/CHX. *(J Endod 2009;■:1–4)*

Key Words

ActiV GP, AH plus, bond strength, chlorhexidine, EDTA, MTAD

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Successful endodontic therapy depends on thorough chemomechanical preparation of the root canal system as well as three-dimensional obturation that provides complete sealing of the spaces previously occupied by the canal contents (1). Mechanical instrumentation usually results in an amorphous irregular smear layer covering the canal dentinal surfaces and plugging the dentinal tubules (2). The alternating use of EDTA and sodium hypochlorite (NaOCl) has long been proved efficient in removing endodontic smear layer (3). On the other hand, they lack sustained antimicrobial capacity (4).

Chlorhexidine gluconate (CHX) has been suggested as an alternative irrigating solution that could replace NaOCl. CHX is bactericidal because of its ability to precipitate and coagulate bacterial intracellular constituents (5). Furthermore, its antibacterial action would persist in root canal for 12 weeks after its use as an endodontic irrigant (6, 7).

Recently, another endodontic irrigant containing 3% doxycycline hyclate, 4.25% citric acid, and 0.5% polysorbate 80 detergent has been introduced as MTAD. This irrigant is recommended as a final rinse after initial irrigation with 1.3% NaOCl (8). MTAD has been shown to be a clinically effective, biocompatible (9), endodontic irrigant with potential sustained antibacterial activity (10). Both MTAD and EDTA were able under mechanical agitation to completely eliminate the endodontic smear layer and smear plugs and to create layers of demineralized collagen matrices in the root canal dentin walls (11).

Among the required physical properties of filling materials, adhesion was found to be a very desirable property in root canal cements. Ideal endodontic cement must seal the root canal space and should adhere to both the gutta-percha core and canal wall (12). Epoxy resin-based sealer cements such as AH Plus sealer (Dentsply, Detrey, GmbH, Germany) have been widely used because of their acceptable physical properties, reduced solubility, apical sealability, microretention to root dentin, and adequate biological performance (13, 14).

Recently, manufacturers have introduced adhesive dentistry to the field of endodontics with a specific focus on obtaining a “monobloc” in which the core material, sealing agent, and the root canal dentin form a single cohesive unit (15). ActiV GP (Brasseler USA, Savannah, GA) is a new glass-ionomer root canal–filling system that has been marketed as to create a single-cone monoblock obturation. The system comprises glass ionomer impregnated and coated gutta-percha cones that are bondable to a sealing agent composed of barium aluminosilicate glass powder and polyacrylic acid (16). This was claimed to offer adhesive bonding of core material to intraradicular dentin via the glass-ionomer sealer (17). Few studies have investigated the degree of bonding and adaptation of this material to root canal dentin (15, 18–20), but to date no study has determined the effect of different irrigants on the sealer-dentin bond strength when using the ActiV GP obturation system. Therefore, the aim of this study was to assess and compare the bond strength of the ActiV GP root canal obturating system and gutta-percha/AH plus sealer when used after various irrigation regimens.

Materials and Methods

Forty recently extracted human single-rooted teeth were collected and used in this study. The teeth were thoroughly cleaned by removing the hard deposits using curettes and the soft deposits by soaking in NaOCl 5.25% for 30 minutes. The teeth were then

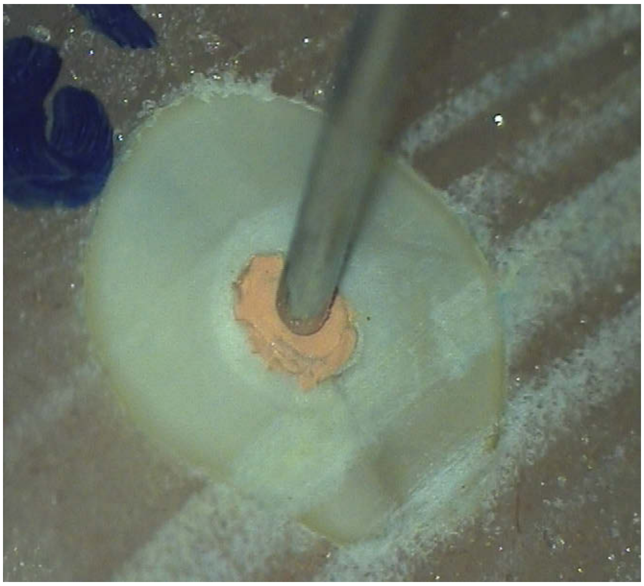

Figure 1. The 0.8-mm plunger adjusted to the root canal filling during the push-out bond test.

stored in distilled water. Before canal instrumentation, decoronation of the teeth was performed by using a high-speed carbide bur and water spray to obtain approximately 16-mm long root segments. Canal patency and working length were established by inserting K file #15 (Mani, Inc, Tochigi, Japan) to the root canal terminus and subtracting 1 mm from this measurement. This step was performed under 8× using surgical microscope (Opmi-Pico; Karl Zeiss, Jena, Germany). The root canals were instrumented using K3 0.06 taper nickel-titanium rotary instruments (SybronEndo Europe, Amersfoort, The Netherlands). Each canal was enlarged to size #40 at the working length. Irrigation with 3 mL of 2.6% sodium hypochlorite was performed between each file size.

The roots were then randomly divided into four groups (n = 10) according to the final irrigation regimen: group 1, 5 mL 17% EDTA (Odahcam, Dentsply, Latin America, Petrópolis, RJ, Brazil); group 2, 5 mL 17% EDTA followed by 5 mL 2% CHX (Consepsis, Ultradent, South Jordan, UT); group 3, 5 mL MTAD (Biopure, Dentsplay Tulsa Dental, Tulsa, OK); and group 4, 5 mL MTAD followed by 5 ml 2% CHX. The canals were dried using paper points #40/0.04 (Vericom CO, Gyeonggi-Do, Korea). Each group was further subdivided into two subgroups (n = 5) according to the obturation system used.

In subgroup a, the root canals were filled using warm gutta-percha and AH plus root canal sealer (Dentsply, Detrey, GmbH, Germany). After mixing the sealer, a gutta-percha master cone #40/0.06 (META Biomed Co, Ltd, Chwongwon-gun, Korea) was lightly coated with sealer and inserted to the working length. A System B plugger size fine medium (SybronEndo Europe) was used to condense the master cone to within 5 mm from the working length. The coronal and middle thirds of the canals were then filled using Obtura II thermoplasticized technique at 185 °C (Spartan/Obtura, Fenton, MO). In subgroup b, the root canals were filled using ActiV GP. The glass-ionomer sealer was mixed according to manufacturer's instructions. A single ActiV GP #40/0.06 cone was coated with the sealer and slowly inserted into the canal to the working length. The surplus of the cone was removed by using hot system B plugger and a layer of ActiV GP sealer was placed on the top of the cone as recommended by the manufacturer.

The roots were coded and placed in 100% humidity for 48 hours to ensure complete setting of the sealers. Each root was then embedded in epoxy resin in a custom-made split-ring copper mold. After setting of the epoxy resin, three horizontal sections of 2-mm thickness each were cut from coronal and middle thirds of each root by using a water-cooled precision saw (Ernst-Leitz, Wetzlar, Germany). This resulted in 15 horizontal sections per subgroup with a total number of 120 horizontal sections for the four experimental groups. Each section was coded and measured for the apical and coronal diameters of the obturated area using an Olympus Camedia C-5060 digital camera (Tokyo, Japan) attached to a Zeiss stereomicroscope. Each root section was then subjected to a compressive load via a universal testing machine (LIoyd LRX-plus; LIyod Instruments Ltd, Fareham, UK) at a crosshead speed of 1 mm/min using a 0.8-mm diameter stainless steel cylindrical plunger. The plunger tip was positioned so that it only contacted the filling material (Fig. 1). The push-out force was applied in an apicocoronal direction until bond failure occurred, which was manifested by extrusion of the obturation material and a sudden drop along the load deflection. The force was recorded by using Nexygen data analysis software (LIyod Instruments Ltd). The maximum failure load was recorded in newtons and was used to calculate the push-out bond strength in megapascals (MPa) according to the following formula (21):

$$\text{Push-out bond strength (MPa)} = \frac{\text{Maximum load (N)}}{\text{Adhesion area of root canal filling (mm}^2\text{)}}$$

The adhesion (bonding) surface area of each section was calculated as:

$(\pi r_1 + \pi r_2) \times L$. L was calculated as $\sqrt{(r_1 - r_2)^2 + h^2}$, where π is the constant 3.14, r_1 is the smaller radius, r_2 is the larger, and h is the thickness of the section in mm.

Data were presented as mean and standard deviation values. A regression model with two-way analysis of variance was used in testing significance for the effect of material and irrigant and their interactions on mean push-out bond strength. A Tukey post hoc test was used for pair-wise comparison between the means when an analysis of variance test was significant. The significance level was set at $p \leq 0.05$. Statistical analysis was performed with SPSS 15.0 for Windows (SPSS Inc, Chicago, IL).

Results

The mean values of bond strengths recorded for different subgroups are presented in Figure 2. Subroup 2b (EDTA/CHX/ ActiV GP) yielded significantly the highest mean push-out bond strength (2.46 ± 1.02 MPa). On the other hand, the significantly lowest mean push-out bond (1.12 ± 0.72 MPa) was recorded for subgroup 1b (EDTA/ActiV GP). The remaining subgroups revealed intermediate mean values of bond strength. No significant difference was found between subgroups 3b (MTAD/ActiV GP) and 4b (MTAD/CHX/ActiV GP): 2.29 ± 1.12 MPa and 2.25 ± 0.67 MPa, respectively. This was significantly followed by subgroups 1a (EDTA/AH plus) and 2a (EDTA/CHX/AH plus), 2.10 ± 0.51 MPa and 2.04 ± 0.44 MPa, respectively, with no statistically significant difference between them. Meanwhile, a significant difference was found between subgroup 3a (MTAD/AH plus), 1.76 ± 1.67 MPa, and subgroup 4a (MTAD/CHX/AH plus), 1.26 ± 1.02 MPa.

Discussion

Dentin surface treatment with different irrigation regimens may cause alteration in the chemical and structural composition of human dentin, thereby changing its permeability and solubility characteristics (22, 23) and hence affecting the adhesion of materials to

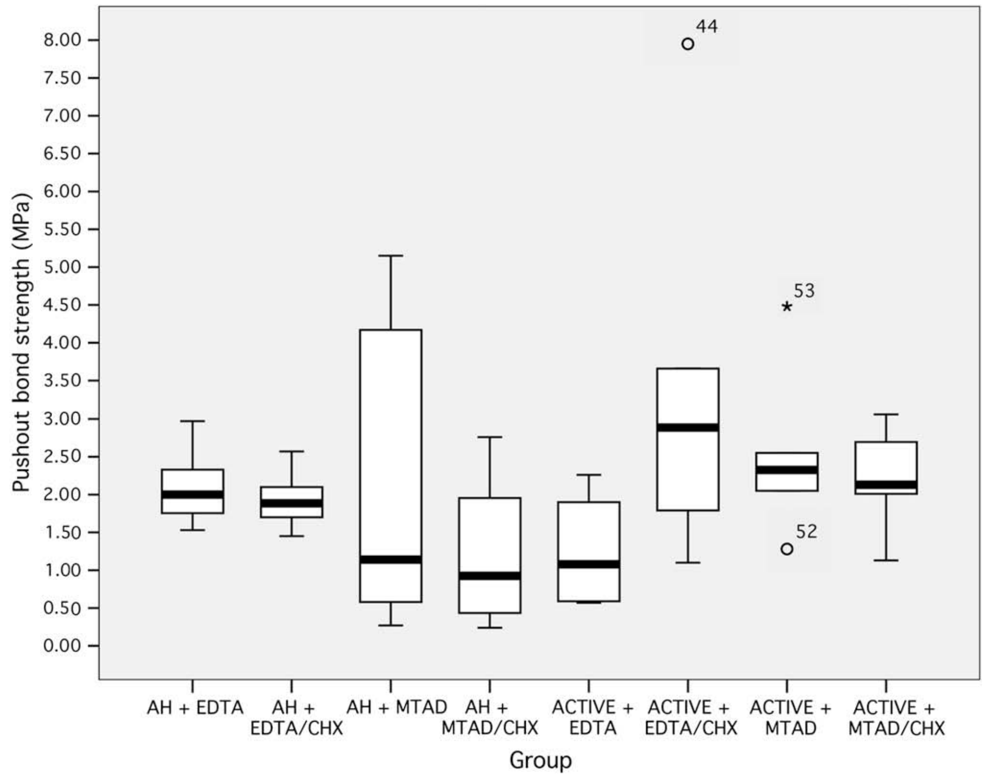

Figure 2. A histogram representing the mean values of bond strength (MPa) and standard deviation of different subgroups.

dentin surfaces (24). Optimum adhesion requires intimate contact between the adhesive material and the substrate to facilitate molecular attraction and allow either chemical adhesion or penetration for micromechanical surface interlocking. Therefore, adhesion processes are mainly influenced by the relative surface energy (wetting ability) of the solid surface (24, 25), which, in turn, is affected by the internal dentin wetness resulting from dentin permeability provided by water in the dentinal tubules (26). This wetness is a consequence of dentin permeability provided by water in the dentinal tubules (26).

In the present study, the bond strength of the tested obturation systems was found to be differently affected by the various irrigation regimens applied. When 17% EDTA was used as a final irrigant, the recorded push-out bond strength values of GP/AH plus agree with those reported by Sly et al (27). Final irrigation with EDTA resulted in higher bond strength values for GP/AH plus than for ActiV GP, which was consistent with another study (15). This could be attributed to the alteration of the dentin surface energy as a result of pretreatment with EDTA. Attal et al (28) and Dogen Buzoglut al (29) reported that EDTA significantly decreased the wetting ability of dentinal wall (ie, decreased surface energy). Therefore, a suitable dentin substrate could be provided for the adhesion of materials with hydrophobic nature as the resinous AH plus. Furthermore, the effective removal of the smear layer by EDTA allowed for the extension of the resin into the open dentinal tubules, creating efficient microretention as previously reported (13, 14). On the contrary, such decreased wetting ability of dentin surface treated with 17% EDTA prohibited the adhesion of materials hydrophilic in nature as ActiV GP.

The use of MTAD as a final irrigant with gutta-percha/AH plus resulted in a significant decrease in its bond strength (1.76 $\pm$ 1.67) compared with EDTA/AH plus. MTAD is acidic (pH = 2.15), containing doxycycline and citric acid among its constituents and resulting in the removal of the smear layer and demineralization of the underlying dentin. According to Tay et al (11), MTAD produced a 10- to 12-μm thick zone of demineralized dentin compared with only a 4- to 6-μm thick zone produced by EDTA. Furthermore, Tween 80 detergent, a constituent of MTAD, permitted increased dentin surface energy and wettability, hence increasing intertubular dentin permeability as well as the exposure of collagen matrix and intertubular fluid, which could have negatively affected the adhesion of the hydrophobic AH plus sealer. On the other hand, final irrigation with MTAD per se in subgroup 3b (MTAD/ActiV GP) provided a good dentinal surface treatment for the adhesion of the glass-ionomer–based sealer. In addition, the chemical bonding capacity of the ActiV GP (a diffusion-based adhesion) would have developed by ion exchange between the glass-ionomer and the tooth surface. The polyalkenoic acid chains penetrate the surface of dentin and displace phosphate ions, releasing them into the cement. Each phosphate ion takes with it a calcium ion to maintain electrolytic balance (30).

The values of push-out bond strength recorded with gutta-percha/AH plus when using either EDTA or MTAD as a final irrigant agree with those reported by De-Dues et al (31). The authors suggested that EDTA and MTAD provided sufficient dentin tubular area as well as depth of demineralization, thus offering the major retention (for resin sealer) through micromechanical interlocking with open dentinal tubules.

Flushing the root canal with CHX after EDTA or MTAD affected the bond strength of obturating materials differently. CHX irrigation after 17%EDTA had significantly doubled bond strength of ActiV GP (2.46 $\pm$ 1.02) in subgroup 2b. This could be attributed to the presence of surface surfactant in CHX composition, which increases the dentin surface energy and, hence, its wettability, a property that is required for the adhesion of ActiV GP. Moreover, CHX enhanced the cationic charging of the dentin surface, thus increasing the reaction of polycarboxylic group of the glass ionomer (32, 33). On the other hand, a final rinse with CHX after MTAD was of no significant effect on the bond strength of ActiV GP. MTAD already contains Tween 80 that enhances dentin surface energy and surface wettability, which would, in turn, have increased dentin permeability as well as penetration and diffusion into the dentinal tissues. Despite the fact that the final irrigation with CHX after 17% EDTA was of no significant effect on the bond strength of GP/AH plus (2.04 $\pm$ 0.44), its use after MTAD resulted in a significant decrease in the bond strength of GP/AH plus when compared with the use of MTAD per se. This is in agreement with another study (3) and may be attributed to the combined action of CHX and Tween 80 increasing the dentin permeability and prohibiting the penetration of hydrophobic AH plus sealer into exposed demineralized collagen matrix, hence interfering with adhesion of the resinous material (34, 35).

Within the limitations of this study, it could be concluded that 1) bonding strength of ActiV GP can be improved by final irrigation with 17% EDTA followed by 2% CHX, 2) CHX does not enhance the effect of MTAD on ActiV GP bond strength, and 3) the bond strength of GP/AH plus was adversely affected by MTAD and MTAD/CHX.

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