

## ORIGINAL ARTICLE

**Effects of different irrigating solutions and disinfection methods on push-out bond strengths of fiber posts**HUSEYIN ERTAS<sup>1</sup>, EVREN OK<sup>2</sup>, BANU UYSAL<sup>1</sup> & HAKAN ARSLAN<sup>1</sup><sup>1</sup>Department of Endodontics, Faculty of Dentistry, Izmir Katip Celebi University, Izmir, Turkey, and <sup>2</sup>Department of Endodontics, Faculty of Dentistry, Sifa University, Izmir, Turkey**Abstract**

**Objective.** The aim of this study was to evaluate the effects of various irrigating solutions and photoactivated disinfection (PAD) on the push-out bond strengths of fiber posts to root dentin. **Materials and methods.** Thirty-two human teeth were divided into eight groups, as follows: (1) irrigation with physiologic saline (control), (2) NaOCl irrigation, (3) chlorhexidine (CHX) irrigation, (4) ethanol (EtOH) irrigation, (5) NaOCl followed by 17% EDTA irrigation, (6) NaOCl-EDTA supplemented with CHX irrigation, (7) NaOCl-EDTA supplemented with EtOH irrigation and (8) NaOCl-EDTA irrigation supplemented with PAD. After the posts were cemented, the roots were transversally sectioned to obtain four slices (1 mm thick) ( $n = 16$ ). Push-out tests were conducted by applying a load at 0.5 mm/min, types of fracture failures were recorded and data were analyzed with one-way ANOVA and Tukey post-hoc tests ( $p = 0.05$ ). **Results.** Push-out bond strength was significantly affected by the type of irrigating solution and the disinfection protocol ( $p < 0.05$ ). The bond strength of the EtOH, NaOCl and NaOCl-EDTA-CHX irrigated groups was significantly higher than that of the other groups. The highest bond strength was observed in the EtOH irrigated group and the lowest was the NaOCl-EDTA irrigated group. **Conclusions.** Irrigation with NaOCl and EDTA combined caused lower bond strength than observed in the control group. However, supplementing this combination with CHX improved the post-dentin bond strengths; supplementing with PAD did not.

**Key Words:** bond strength, chlorhexidine, ethanol, fiber post, photoactivation

**Introduction**

Restoring endodontically treated teeth with fiber posts to retain coronal restoration has become popular, since fiber posts have a modulus of elasticity close to that of dentin [1,2]. The other advantages of fiber posts are their good esthetic appearance, with no risk of gingival discoloration of the root surfaces by corrosive products [3]. Nevertheless, removing the root canal filling while preparing the post space without rubber dam isolation or inadequate temporary restorations may cause invasion of oral fluids and micro-organisms into the canal, which could result in failure of the endodontic treatment [4]. Another concern while preparing the post space is a debris and smear layer forming on canal walls, leading to increased leakage and obstruction of the dentin tubules, thus blocking the adhesive luting of the fiber post [5].

Sodium hypochlorite (NaOCl) is widely used in root canal treatment because NaOCl can dissolve organic tissue and for its antimicrobial properties [6,7]. However, because NaOCl influences only the organic components of the smear layer, this irrigating solution is used with a demineralizing agent such as ethylenediaminetetraacetic acid (EDTA) [8,9]. Chlorhexidine digluconate (CHX), another widely used irrigating solution, has been suggested because of its antimicrobial properties, substantivity, and effect on the longevity of composite adhesive bonding to dentin [10–12].

Recently, photoactivated disinfection (PAD) has become available as an adjunct to endodontic treatment. Light of an appropriate wavelength activates a photosensitizing molecule that leads to liberating reactive oxygen, which attaches to the bacterial/fungal membrane and in this way kills the bacteria [13,14]. However, although PAD has been reported

as a supplement to the existing protocol for root canal disinfection [15], to date no data are available on the effect of this treatment on the bonding strengths of fiber posts and luting agents.

As effective bonding between the post, dentin, and adhesive resin cement and its durability are essential for a restoration to last [16], the effects of various irrigating solutions and disinfection methods on post-dentin bond strengths should be evaluated. Thus, the aim of this study was to evaluate the effects of various irrigating solutions and disinfection methods on the push-out bond strengths of fiber posts to root dentin. The null hypothesis was that various irrigating solutions and disinfection methods do not affect the push-out bond strengths of fiber posts to root dentin.

### Materials and methods

Thirty-two single-rooted freshly extracted human teeth with approximately the same dimensions were selected and stored in daily-changed distilled water until they were used. Soft tissues and calculus were mechanically removed from the root surfaces with a scaler. The crowns were sectioned using a water-cooled Isomet saw (Buehler, Lake Bluff, IL) to obtain a standardized root height of 15 mm. Teeth with ribbon-shaped root canals at the cut surface were excluded from the study. Working length was determined by subtracting 1 mm from the mm at which the #10 K-file (Dentsply, Maillefer, Ballaigues, Switzerland) was just visible through the apical foramen. The root canals were prepared using ProTaper rotary instruments (Dentsply, Switzerland) up to an apical preparation with size #40 (F4). Root canals were irrigated with 1 mL 2.5% NaOCl between instrument changes. The root specimens were dried with paper points and filled with gutta-percha-AH Plus sealer (Dentsply DeTrey, Kontanz, Germany) using cold lateral condensation.

After the specimens were stored for 24 h in 100% humidity, the coronal part of the root canal filling material was removed with Gates Glidden burs (Dentsply, Switzerland). The remaining filling material was removed using a 1.5-mm post drill at 5000 rpm (Ultradent Products Inc, South Jordan,

UT) to create a 10-mm deep post space, leaving more than 4 mm gutta-percha to preserve the apical seal. The specimens were then divided into eight groups, as follows:

- Group 1 (Physiologic saline) (NaCl): In this group, specimens were irrigated with 5 ml 0.9% NaCl for 5 min (control).
- Group 2 (NaOCl): The specimens were irrigated with 5 ml 5.25% NaOCl for 5 min.
- Group 3 (CHX): The post spaces were irrigated with 5 ml 2% CHX for 5 min.
- Group 4 (EtOH): The post spaces were irrigated with 5 ml 100% EtOH for 5 min.
- Group 5 (NaOCl-EDTA): The specimens were irrigated with 5 ml 5.25% NaOCl for 5 min and 5 ml 17% EDTA for 5 min.
- Group 6 (NaOCl-EDTA-CHX): The post spaces were irrigated with 5 ml 5.25% NaOCl for 5 min and with 5 ml 17% EDTA for 5 min. For the final flush, they were irrigated with 5 ml distilled water and 2% chlorhexidine for 5 min.
- Group 7 (NaOCl-EDTA-EtOH): The post spaces were irrigated with 5 ml 5.25% NaOCl for 5 min and with 5 ml 17% EDTA for 5 min. For the final flush, they were irrigated with 5 ml distilled water and 5 ml 100% EtOH for 5 min.
- Group 8 (NaOCl-EDTA-PAD): After irrigating with 5 ml 5.25% NaOCl, followed by 5 ml 17% EDTA for 5 min, the PAD solution (FotoSan Agent [CMS Dental, Copenhagen, Denmark] fotosensitizer; medium viscosity, containing 0.01% toluidine blue O) was injected into the canal using a sterile endodontic micro needle (27 gauge). The liquid was then agitated in each canal for 60 s using #30 K-file. The PAD emitter (FotoSan; CMS Dental) was inserted 3 mm above the apical part of the post space and light cured (15 W light-emitting diode [LED], output intensity of 2000 mW/cm<sup>2</sup>, wavelength of 625–635 nm) for 20 s. Finally, the post spaces of the specimens were irrigated with 15 ml distilled water.

The post spaces were dried with paper points and 1.5-mm fiber posts (UniCore, Ultradent Products Inc, South Jordan, UT) were cemented into the root canals using Bifix SE dual-cured resin cement

Table I. Summary of the procedures in the study according to manufacturers' suggestion.

|  |   |
|--|---|
| Voco GmbH Cuxhaven, Germany (Cement type: Bifix SE)                                      | Ultradent Products Inc, South Jordan, UT (Post type: UniCore) |
| Prepare post space   | Sterilize the posts with alcohol prior to use                 |
| Disinfect the root canal   | Insert post into the canal                                    |
| Dry the root canal and dentine with paper points, leaving the dentine slightly moist     | Remove the excess of the dual-cured Bfix SE cement            |
| Apply Bifix SE directly into the root canal beginning from apical part of the post space | Light-cure for 40 s   |

(Voco GmbH, Cuxhaven, Germany). Post luting procedures were performed according to the manufacturer's suggestions (Table I).

Each specimen was cut transversally from the middle third of the root canals with an Isomet saw under water coolant to produce four slices of ~1 mm thick ( $n = 16$ ). The thickness of each slice was measured using a digital caliper and recorded as height ( $h$ ). The bonding area was calculated for each slice using the following formula:  $\pi (R + r) [(h^2 + (R - r)^2)^{0.5}]$  ( $R$ : coronal root canal radius,  $r$ : apical root canal radius). Push-out bond strengths were carried out with a universal testing machine (Instron Corp., Norwood, MA) by applying a load at 0.5 mm/min apical to the coronal direction until fracture occurred. Push-out bond strength in MPa was calculated by dividing the peak force by the bonded area of the post segment. The failure mode of each slice was assessed under a stereomicroscope (OPMI Pico, Carl Zeiss, Germany) at  $25\times$  magnification to classify the failure pattern into four types: (1) adhesive failure between the post and the luting material, (2) adhesive failure between the dentin and the luting material, (3) mixed failure (combination of 2 of the above) and (4) cohesive failure of the dentine. The percentages of the failure types within each group were then calculated.

The Shapiro-Wilk statistical test for normality revealed a normal data distribution. Statistical analysis was carried out using one-way ANOVA and Tukey post-hoc tests for the push-out bond strength data ( $\alpha = 0.05$ ). All statistical analyses were performed using the SPSS software version 16.0 (SPSS Inc., Chicago, IL).

## Results

Table II shows the mean bond strength and standard deviations and the distribution of the failure types for

each group. Push-out bond strength varied statistically significantly according to the type of irrigation and the disinfection protocol ( $p < 0.05$ ). The bond strength of the EtOH-, NaOCl- and NaOCl-EDTA-CHX-irrigated groups was significantly higher than that of the other groups ( $p < 0.05$ ). The bond strength of the CHX- and NaOCl-irrigated groups was similar to that of the NaOCl-EDTA-, NaOCl-EDTA-EtOH- and NaOCl-EDTA-PAD-irrigated groups ( $p > 0.05$ ).

## Discussion

The aim of this study was to evaluate the effects of various irrigating solutions and disinfection methods on the push-out bond strengths of fiber posts to root dentin. Standard NaOCl was used as the irrigating solution in all groups during root canal treatment and root canals were filled with AH plus/gutta-percha. After the test solutions and disinfection method were applied, the root canals were rinsed with distilled water to end the actions of the test materials.

The time interval between filling a root canal and preparing the post space and placing the post is important, because the setting of the sealing affects post-dentin interfacial leakage or strength [17]. Vano et al. [18] evaluated this issue in two studies and found that delayed cementation of fiber posts showed higher strength than immediate cementation. They also stated that bond strengths in the 24-h and 1-week groups were similar. In the other study, the authors demonstrated that delayed cementation of fiber posts resulted in higher retentive strengths when epoxy resin sealer was used [19]. In the present study, we used AH Plus, an epoxy resin sealer. Therefore, we preferred 24-h delayed cementation because its strength is similar to 1 week.

The present study demonstrated that the NaOCl irrigating solution used alone did not decrease the post-dentin bond strength. Cecchin et al. [20] found

Table II. The mean bond strength and standard deviations and the distribution of failures with percentages.

| Groups             | $n$ | Mean (Mpa)         | SD  | Failure modes                 |                                     |            |                             |    |     |   |     |
|--------------------|-----|--------------------|-----|-------------------------------|-------------------------------------|------------|-----------------------------|----|-----|---|-----|
|                    |     |                    |     | 1<br>Adhesive:<br>post-cement | 2<br>Adhesive:<br>cement-<br>dentin | 3<br>Mixed | 4<br>Cohesive:<br>in dentin |    |     |   |     |
| Physiologic saline | 16  | 9.2 <sup>abc</sup> | 3.4 | 2                             | 13%                                 | 6          | 38%                         | 8  | 50% | 0 | 0%  |
| NaOCl              | 16  | 12.2 <sup>c</sup>  | 3.6 | 1                             | 6%                                  | 1          | 6%                          | 13 | 81% | 1 | 6%  |
| CHX                | 16  | 8.3 <sup>ab</sup>  | 4.2 | 0                             | 0%                                  | 9          | 56%                         | 7  | 44% | 0 | 0%  |
| EtOH               | 16  | 12.3 <sup>c</sup>  | 3.7 | 2                             | 13%                                 | 1          | 6%                          | 12 | 75% | 1 | 6%  |
| NaOCl-EDTA         | 16  | 6.6 <sup>a</sup>   | 2.6 | 1                             | 6%                                  | 6          | 38%                         | 9  | 56% | 0 | 0%  |
| NaOCl-EDTA-CHX     | 16  | 11.3 <sup>bc</sup> | 3.2 | 1                             | 6%                                  | 3          | 19%                         | 10 | 63% | 2 | 13% |
| NaOCl-EDTA-EtOH    | 16  | 7.1 <sup>a</sup>   | 2.6 | 0                             | 0%                                  | 8          | 50%                         | 8  | 50% | 0 | 0%  |
| NaOCl-EDTA-PAD     | 16  | 7.3 <sup>a</sup>   | 2.9 | 0                             | 0%                                  | 4          | 25%                         | 11 | 69% | 1 | 6%  |

Note: Different superscript letters between means of groups represent statistically significant differences ( $p < 0.05$ ).

that NaOCl preserved the bond strength immediately and for 12 months. This study finding was in agreement with our result.

The effectiveness of the NaOCl-EDTA combination in removing the smear layer from the root canal walls is well documented in endodontics [21,22]. Kambara et al. [23] demonstrated that NaOCl-EDTA affected the bond strength between the cement and dentin interface because of the materials' hydrophobic/hydrophilic properties. Similarly, in the present study the NaOCl-EDTA combination decreased the bond strength of the fiber posts to the root canals.

Recently, PAD has become popular in endodontics as a disinfection method. However, although PAD is effective in killing bacteria in root canals [14,24–26], limited data are available about its effect on bonding strengths. Thus, one of the aims of this study was to examine the effect of PAD on post-dentin bond strength. The present study showed that supplementing the NaOCl-EDTA combined irrigation with the PAD disinfection method did not result in a significant change in bond strength, compared to the NaOCl-EDTA combination. However, supplementing NaOCl-EDTA with PAD did not increase the bond strength as CHX did.

Previous studies have demonstrated that CHX inhibits matrix metalloproteinases and improves the stability of hybrid layer integrity [3,27–29]. An interesting finding in the present study was that the NaOCl-EDTA combinations decreased the post-dentin bond strength; however, the NaOCl-EDTA combination supplemented with CHX had higher bond strength than the other NaOCl-EDTA combinations. CHX has been suggested as an irrigant and as an intra-canal medicament in root canal treatment because of its antimicrobial activity and long-term continued effect [11,30,31]. Moreover, previous studies demonstrated that CHX inhibits matrix metalloproteinases enzymes, which may be responsible for degrading the hybrid layer [27,28]. This could be an explanation for the increased bond strength values for the NaOCl-EDTA combination supplemented with CHX shown in the present study.

Egilmez et al. [32] found that using CHX solution alone for antibacterial effects did not have beneficial effects on the bond strengths of cements. Cecchin et al. [3] observed a significant bond strength decrease when irrigations involving CHX were performed. Similarly, the results of this study demonstrated that a single use of CHX decreased the post-dentin bond strength. These results were also in agreement with those of Pelegrine et al. [33], Cecchin et al. [29] and Lindblad et al. [34].

Previous reports demonstrated that EtOH can form a more stable hybrid layer due to the ability to replace water from dentin [35,36]. EtOH is expected to provide monomers to penetrate the dentin in the

same way. According to our results, the highest bonding strength values were in the EtOH group. However, supplementing the NaOCl-EDTA combination with EtOH did not result in improved bond strengths. This result was in agreement with that of Cecchin et al. [3], who used acid-etched dentin.

Regarding the fracture analysis, the adhesive and mixed types of failure were the predominant types of failure. There were fewer cohesive failures than the other types of failures, which shows that the bond strength to dentin was weaker compared with the shear bond strength of the dentin itself [37].

## Conclusions

Within the limitations of this study, the following conclusions can be drawn:

- (1) Different root canal protocols resulted in varying alterations in post-dentin bond strength.
- (2) The NaOCl-EDTA combination resulted in reduced post-dentin bond strengths; however, supplementing the NaOCl-EDTA combination with CHX improved the post-dentin bond strength.
- (3) PAD with the NaOCl-EDTA combination did not affect the post-dentin bond strength.

**Declaration of interest:** The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

## References

- [1] Asmussen E, Peutzfeldt A, Heitmann T. Stiffness, elastic limit, and strength of newer types of endodontic posts. *J Dent* 1999;27:275–8.
- [2] Schwartz RS, Robbins JW. Post placement and restoration of endodontically treated teeth: a literature review. *J Endod* 2004;30:289–301.
- [3] Cecchin D, de Almeida JF, Gomes BP, Zaia AA, Ferraz CC. Influence of chlorhexidine and ethanol on the bond strength and durability of the adhesion of the fiber posts to root dentin using a total etching adhesive system. *J Endod* 2011;37:1310–15.
- [4] Mavec JC, McClanahan SB, Minah GE, Johnson JD, Blundell RE Jr. Effects of an intracanal glass ionomer barrier on coronal microleakage in teeth with post space. *J Endod* 2006;32:120–2.
- [5] Gu XH, Mao CY, Kern M. Effect of different irrigation on smear layer removal after post space preparation. *J Endod* 2009;35:583–6.
- [6] Zehnder M. Root canal irrigants. *J Endod* 2006;32:389–98.
- [7] Gutierrez JH, Jofre A, Villena F. Scanning electron microscope study on the action of endodontic irrigants on bacteria invading the dentinal tubules. *Oral Surg Oral Med Oral Pathol* 1990;69:491–501.
- [8] Lottanti S, Gautschi H, Sener B, Zehnder M. Effects of ethylenediaminetetraacetic, etidronic and peracetic acid irrigation on human root dentine and the smear layer. *Int Endod J* 2009;42:335–43.

- [9] Goldman M, Goldman LB, Cavaleri R, Bogis J, Lin PS. The efficacy of several endodontic irrigating solutions: a scanning electron microscopic study: part 2. *J Endod* 1982;8:487-92.
- [10] Gomes BP, Ferraz CC, Vianna ME, Berber VB, Teixeira FB, Souza-Filho FJ. In vitro antimicrobial activity of several concentrations of sodium hypochlorite and chlorhexidine gluconate in the elimination of *Enterococcus faecalis*. *Int Endod J* 2001;34:424-8.
- [11] Carrilho MR, Carvalho RM, Sousa EN, Nicolau J, Breschi L, Mazzoni A, et al. Substantivity of chlorhexidine to human dentin. *Dent Mater* 2010;26:779-85.
- [12] Ricci HA, Sanabe ME, de Souza Costa CA, Pashley DH, Hebling J. Chlorhexidine increases the longevity of in vivo resin-dentin bonds. *Eur J Oral Sci* 2010;118:411-16.
- [13] Bonstein T, Mikulski LM, Bush MA, Bush PJ. Photoactivated disinfection of *Streptococcus intermedius* through dentin disc at clinically relevant intervals: an in vitro study. *Arch Oral Biol* 2010;55:771-7.
- [14] Schlafer S, Vaeth M, Horsted-Bindslev P, Frandsen EV. Endodontic photoactivated disinfection using a conventional light source: an in vitro and ex vivo study. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2010;109:634-41.
- [15] Bergmans L, Moisiadis P, Huybrechts B, Van Meerbeek B, Quirynen M, Lambrechts P. Effect of photo-activated disinfection on endodontic pathogens ex vivo. *Int Endod J* 2008;41:227-39.
- [16] Bonfante EA, Pegoraro LF, de Goes MF, Carvalho RM. SEM observation of the bond integrity of fiber-reinforced composite posts cemented into root canals. *Dent Mater* 2008;24:483-91.
- [17] Abramovitz I, Tagger M, Tamse A, Metzger Z. The effect of immediate vs. delayed post space preparation on the apical seal of a root canal filling: a study in an increased-sensitivity pressure-driven system. *J Endod* 2000;26:435-9.
- [18] Vano M, Cury AH, Goracci C, Chieffi N, Gabriele M, Tay FR, et al. The effect of immediate versus delayed cementation on the retention of different types of fiber post in canals obturated using a eugenol sealer. *J Endod* 2006;32:882-5.
- [19] Vano M, Cury AH, Goracci C, Chieffi N, Gabriele M, Tay FR, et al. Retention of fiber posts cemented at different time intervals in canals obturated using an epoxy resin sealer. *J Dent* 2008;36:801-7.
- [20] Cecchin D, Almeida JF, Gomes BP, Zaia AA, Ferraz CC. Deproteinization technique stabilizes the adhesion of the fiberglass post relined with resin composite to root canal. *J Biomed Mater Res B Appl Biomater* 2012;100B:577-83.
- [21] Lotfi M, Vosoughhosseini S, Saghiri MA, Zand V, Ranjkesh B, Ghasemi N. Effect of MTAD as a final rinse on removal of smear layer in ten-minute preparation time. *J Endod* 2012;38:1391-4.
- [22] Violich DR, Chandler NP. The smear layer in endodontics - a review. *Int Endod J* 2010;43:2-15.
- [23] Kambara K, Nakajima M, Hosaka K, Takahashi M, Thanatvarakorn O, Ichinose S, et al. Effect of smear layer treatment on dentin bond of self-adhesive cements. *Dent Mater J* 2012;31:980-7.
- [24] Williams JA, Pearson GJ, Colles MJ. Antibacterial action of photoactivated disinfection {PAD} used on endodontic bacteria in planktonic suspension and in artificial and human root canals. *J Dent* 2006;34:363-71.
- [25] Yao N, Zhang C, Chu C. Effectiveness of photoactivated disinfection (PAD) to kill *enterococcus faecalis* in planktonic solution and in an infected tooth model. *Photomed Laser Surg* 2012;30:699-704.
- [26] Poggio C, Arciola CR, Dagna A, Florindi F, Chiesa M, Saino E, et al. Photoactivated disinfection (PAD) in endodontics: an in vitro microbiological evaluation. *Int J Artif Organs* 2011;34:889-97.
- [27] Carrilho MR, Carvalho RM, de Goes MF, di Hipolito V, Geraldini S, Tay FR, et al. Chlorhexidine preserves dentin bond in vitro. *J Dent Res* 2007;86:90-4.
- [28] Carrilho MR, Geraldini S, Tay F, de Goes MF, Carvalho RM, Tjaderhane L, et al. In vivo preservation of the hybrid layer by chlorhexidine. *J Dent Res* 2007;86:529-33.
- [29] Cecchin D, de Almeida JF, Gomes BP, Zaia AA, Ferraz CC. Effect of chlorhexidine and ethanol on the durability of the adhesion of the fiber post relined with resin composite to the root canal. *J Endod* 2011;37:678-83.
- [30] Ferraz CC, Gomes BP, Zaia AA, Teixeira FB, Souza-Filho FJ. In vitro assessment of the antimicrobial action and the mechanical ability of chlorhexidine gel as an endodontic irrigant. *J Endod* 2001;27:452-5.
- [31] de Lucena JM, Decker EM, Walter C, Boeira LS, Lost C, Weiger R. Antimicrobial effectiveness of intracanal medications on *Enterococcus faecalis*: chlorhexidine versus octenidine. *Int Endod J* 2013;46:53-61.
- [32] Egilmez F, Ergun G, Cekic-Nagas I, Vallittu PK, Lassila LV. Bond strength of self-adhesive resin cements to dentin after antibacterial and chelating solution treatment. *Acta Odontol Scand* 2013;71:22-31.
- [33] Pelegrine RA, De Martin AS, Cunha RS, Pelegrine AA, da Silveira Bueno CE. Influence of chemical irrigants on the tensile bond strength of an adhesive system used to cement glass fiber posts to root dentin. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2010;110:e73-6.
- [34] Lindblad RM, Lassila LV, Salo V, Vallittu PK, Tjaderhane L. Effect of chlorhexidine on initial adhesion of fiber-reinforced post to root canal. *J Dent* 2010;38:796-801.
- [35] Tay FR, Pashley DH, Kapur RR, Carrilho MR, Hur YB, Garrett LV, et al. Bonding BisGMA to dentin—a proof of concept for hydrophobic dentin bonding. *J Dent Res* 2007;86:1034-9.
- [36] Pashley DH, Tay FR, Carvalho RM, Rueggeberg FA, Agee KA, Carrilho M, et al. From dry bonding to water-wet bonding to ethanol-wet bonding. A review of the interactions between dentin matrix and solvated resins using a macromodel of the hybrid layer. *Am J Dent* 2007;20:7-20.
- [37] Zorba YO, Erdemir A, Turkyilmaz A, Eldeniz AU. Effects of different curing units and luting agents on push-out bond strength of translucent posts. *J Endod* 2010;36:1521-5.