EGYPTIAN
DENTAL JOURNAL

Vol. 63, 793:798, January, 2017

I.S.S.N 0070-9484

Fixed Prosthodontics, Dental materials, Conservative Dentistry and Endodontics

www.eda-egypt.org • Codex : 53/1701

EFFECTS OF ADDING SILVER NANOPARTICLES ON THE BONDING OF ADHESIVE SYSTEM TO CEMENT GLASS FIBER POSTS

Mohamed I. Ebrahim* *and* Ammar Al Shamrani**

ABSTRACT

Objective: The present study was conducted to evaluate effects of adding silver nanoparticles with 0.5% nanoparticles on the bonding of adhesive system to cement glass fiber posts.

Materials and methods: Twenty human maxillary canines were selected, the coronal portion was sectioned and teeth were endodontically instrumented and obturated with gutta percha. Gutta percha was removed using Largo drills, and then root canal walls of each sample were enlarged with the low-speed burs provided by the manufacturers. The depth of the post space preparation was 10 mm, measured from the cementoenamel junction. The samples were randomly divided into two groups according to adhesive system used. Group A: Adhesive system without additives and Group B: Adhesive system containing 0.5%nanoparticles of silver (NAg). Clearfil SE bond applied without and with additives of (NAg) then cured for 20 seconds using light emitting diodes. RelyX ARC resin cement was introduced into canal and posts were positioned and light-cured for 40 seconds then tensile test was done and recorded values of bond strengths in (MPa) were collected, tabulated and statistically analyzed. One way analysis of variance (ANOVA) and Tukey's tests were used for testing the significance between the means of tested groups which are statistically significant when the P value ≤ 0.05.

Results: Tensile strength of adhesive system containing (NAg) (group B) [11.42MPa] had a statistically higher value than adhesive system without (NAg) (group A) [7.99MPa].

Conclusions: The results indicate that (NAg) with concentration 0.5% increase tensile bond strength of the adhesive system.

INTRODUCTION

Root canal filled teeth had a greater loss of tooth structure, resulting from caries, earlier restorations, fractures, and endodontic access preparation.

The use of posts in endodontically treated teeth with insufficient coronal tooth structure is a universal accepted procedure[1].

Initial post systems were retentive to root canals mechanically; therefore, there is much loss of tooth

* Assistant Professor of Dental Biomaterials, Faculty of Dental Medicine Al Azhar University, Cairo (Boys).
** Assistant Professor of Restorative Dentistry, Dean of Faculty of Dentistry, University of Taif. KSA

structure[2]. Cast metal posts were traditionally used for intraradicular retention and have shown high survival rates after 10 years[3].

As metal posts have been hypothesized to have high elastic moduli in comparison with that of dentin, which could increase the risks of root fracture and catastrophic failure[4], glass fiber posts were introduced as an alternative. As the mechanical properties of these posts are similar to that of dentin, the risk of catastrophic failure is reduced[5] and most failures related to their use involve post debonding[6]. With the evolution of adhesive systems and resin cements endodontically treated teeth began to be reconstructed conservatively[7-11]. Nevertheless, obtaining an effective adhesion to root canals is a challenge, considering their unfavorable geometry and the limitations inherent to the physical-chemical properties of adhesive materials[12].

Many of limitations are related to polymerization shrinkage that often exceeds the bond strength of adhesives to dentin, resulting in gap formation along the surfaces with the weakest bonds[13].

In order to place intraradicular posts in root canals, which are completely filled, gutta percha should be removed with hand or rotary instruments. In both methods, mechanical removal of sealer-impregnated dentin from canal walls is recommended before cementing the posts. Otherwise a fresh surface for resin cement to penetrate and to bond will not be obtained and the retention of cements will be compromised[14,15]. Removal of this impregnated dentin produces a smear layer rich in sealers. This layer should either be removed or penetrated through by the adhesive system. Some studies recommend removal of this layer by chemical irrigants like EDTA and sodium hypochlorite. However, these agents may affect bonding of resin cement to radicular dentin[16,17].

The resin containing NAg inhibit not only bacteria on its surface, but also bacteria in the culture medium away from its surface due to Ag ion[18]. NAg was recently incorporated into dental resins[19]. Their small particle size and large surface area could enable them to release more Ag ions at a low filler level, thereby reducing Ag particle concentration necessary for efficacy[20,21].

The purpose of this study was to to evaluate effects of adding silver nanoparticles with 0.5% nanoparticles on the bonding of adhesive system to cement glass fiber posts to root dentin.

MATERIALS AND METHODS

Tooth preparation:

Twenty human maxillary canines with similar root lengths and fully formed apices and without caries, cracks, or previous endodontic treatment were selected for this study with a mean length of 15 mm and cervical diameter ranging from 5 to 5.5 mm in the mesiodistal direction and 7 to 7.5 mm in the buccolingual direction. The teeth were stored in 0.1% thymol solution (Pharmacia Medicamenta, Campinas, Brazil) and the soft tissue deposits were removed with a hand scaler. The coronal portion of each tooth was sectioned using a diamond double-faced disk in a slow-speed handpiece, cooled with air/water spray. The roots were embedded in self-curing acrylic resin (Palavit G, HeraeusKulzer, Wehrheim, Germany) in plastic cylinders to allow for standardized and secure placement during testing.

The teeth were endodontically instrumented at a working length of 0.5 mm from the apex to a size #35 master apical file. A step-back technique was used with stainless steel K files (Dentsply Maillefer, Ballaigues, Switzerland), Solutions of 2.5% sodium hypochlorite and 17% ethylene diaminetetraacetic acid (EDTA) were used alternately to irrigate the canals throughout the instrumentation procedure. The canals were filled with gutta percha cones and epoxy resin/calcium hydroxide sealer (Sealer 26; Dentsply Maillefer) with the lateral condensation technique[22].

A 10-mm-deep post space was created to receive a prefabricated glass fiber reinforced post with parallel walls and tapered tip (Reforpost No. 2; Angelus Dental Products, Londrina, Brazil) as follows: a heated instrument was introduced into the root canal to remove the gutta percha, and then # 3 and #4 intracanal drills (Reforpost drills #3 and 4; Angelus Dental Products) were used in a slow speed handpiece to standardize the internal geometry of the root walls.

The samples were randomly divided into two groups of 10 samples each according to the type of bonding agent used. Group A: adhesive system without additives and Group B: adhesive system containing nanoparticles of silver (NAg) with concentration 0.5%. [Nanox Clean® (Nanox Technology S.A., São Carlos, SP, Brazil)]

The self-etch 2-step adhesive system Clearfil SE bond (Kuraray) was applied on the intraradicular preparations. Initially, Clearfil SE primer was introduced to the canal space with the aid of a microbrush and spread for 20 seconds. The excess material was removed by a paper point and Clearfil SE bond applied without and with additives of nanoparticles of silver (NAg) with concentration 0.5%. The adhesive was light cured for 20 seconds using light emitting diodes (LED) [BG-light-LTD, 4002 Plovdiv, 430-490nm, Bulgaria].

RelyX ARC resin cement (3M Espe, St. Paul, MN, USA) was manipulated according to the manufacturer's instructions and introduced into the canal with a Lentulo spiral drill #60 (Dentsply/ Maillefer, Ballaigues) in a low-speed handpiece. The posts were positioned and light-cured for 40 seconds. Cement excess was removed with a microbrush before light-curing. The samples were stored in a humid environment at 37°C for 7 days[23] before testing.

Tensile bond test

For the tensile bond test, an acrylic resin cylinder fitted on top with a metallic loop was made over the coronal portion of the post (Fig. 1). The test specimen was placed in a Universal Testing Machine (model LRX plus II. Fareham, England), and an axial tensile load was applied at 0.5 mm/min until failure.

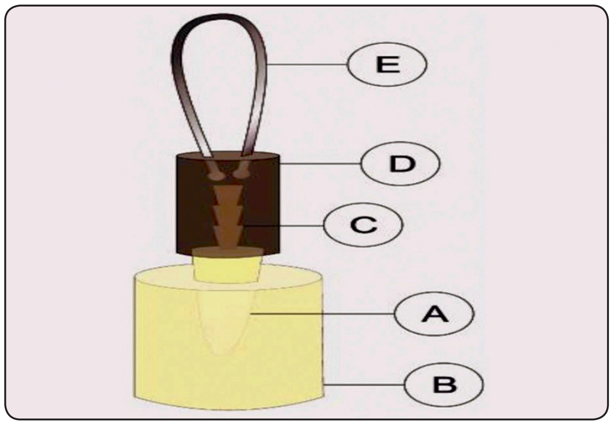

Fig. (1) A, human root; B, acrylic resin; C, glass fiber post; D, acrylic resin cylinder; E, metallic loop.

The tensile bond was calculated by dividing the imposed force at time of failure (F) by the bonded area (mm^2) which calculated by digital caliper (Schnelltaster, Dentaurum, Germany).

Statistical analysis

The loads at failure were recorded and the strength values were calculated and analyzed by one way analysis of variance (ANOVA) and Tukey's tests were used for testing the significance between the means of tested materials which statistically significant when the P value ≤ 0.05.

RESULTS

The means of tensile bond strength for the tested adhesive system without additives and adhesive system containing nanoparticles of silver (NAg) with concentration 0.5% are presented in table 1.

The adhesive system containing nanoparticles of silver (NAg) with concentration 0.5% (group B) showed the statistically significant highest mean tensile bond strength (11.42 MPa) than adhesive system without additives (7.99 MPa) group A.

The results of tensile bond strength showed significant difference (P<0.05) between group B and group A. Tensile bond strength was increased for the specimens containing nanoparticles of silver (NAg).

TABLE (1) Means of tensile bond in (MPa) for the tested adhesive systems.

Group A		Group B		P-value
Mean (MPa)	**SD**	**Mean** (MPa)	**SD**	
7.99[a]	0.14	11.42[b]	0.19	0.001*

Significant at P ≤ 0.05, Means with different letters are significantly different according to Tukey's test.

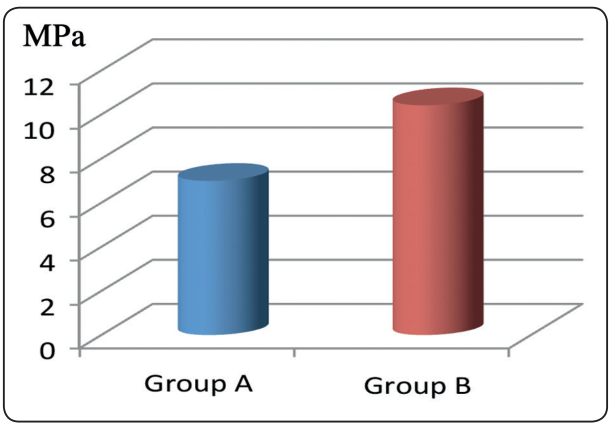

Fig. (2) Mean tensile bond in (MPa) of the tested bond adhesive system groups (group A and group B).

DISCUSSION

The use of glass fiber-reinforced posts has gained popularity in contemporary oral rehabilitative procedures because of their similar elastic modulus as the modulus of elasticity of human radicular dentin[24-27].

Post retention is considered to be a significant factor in the long term success of the definitive restoration[28].

The need for the adhesive luting of glass fiber posts has engendered debates[29,30]. It has been reported that the bonding of glass fiber posts to the dental structure may be related more to the friction of the post along the canal walls than to the adhesive bonding to root dentin[29]. The use of resin cements, however, has been found to significantly increase the retention of fiber posts and improve the fracture resistance of the bonded structures when compared to other cements[31,32]. Adhesive cementation has also been shown to better withstand functional forces[30], improve marginal adaptation with better apical sealing, increase retention with reduced post length[33], and optimize the fracture patterns in case of failures[34].

Although promising results for the use of fiber posts have been reported[35], problems associated with cementation, bond integrity, and interface stability have not been entirely solved[36]. No agreement has been reached as to the ideal system for achieving a strong and durable adhesive interface between glass fiber-reinforced posts and root dentin[37]. Ideally, an interface between the post and dentin should be free of gaps[38] to produce a homogeneous single unit (monobloc), a situation which was originally thought to occur but which remains a theoretical concept[39]. However, the lack of integrity in the entire length of the adhesive interface between the post and dentin has been observed to be more pronounced in the apical portion[36].

The results of the present study demonstrated a significant increase in tensile bond strength of adhesive system containing nanoparticles of silver (NAg) with concentration 0.5% than adhesive system without additives. This may be contributed to NAg-containing bonding agent has antibacterial activity not only on its surface, but also away from its surface. This indicates that NAg-containing resin has a long-distance killing capability, likelydue to the release of Ag ions[40]. It was stated that when NAg are dispersed in bonding agent at low concentrations, thermal and mechanical properties, as well as biological stability and antibacterial action, are improved[41], which reduce or eliminate the interfacial stress concentration within adhesive bonding resin complex[42].

Improvement of strength with addition of nanoparticles of silver (NAg) may have been due to inherent characteristics of the NAg particles. NAg possesses strong ionic interatomic bonding, giving rise to its desirable material characteristics that is tensile strength.

One limitation of this study is that it is an in vitro investigation, which does not fully replicate oral conditions. In addition, this study presents outcomes limited to a single-load test; thus, further studies should add thermal, load cycling, and water storage aging methods to challenge the adhesive interface.

Finally, all proposed luting cements and all adhesive strategies for bonding glass fiber-reinforced posts to root dentin merit further clinical trials to investigate their long-term clinical performance.

CONCLUSION

On the basis of this study, we can conclude that:

Addition of nanoparticles of silver (NAg) with concentration 0.5% on bond adhesive increase tensile bond strength.

Further studies are needed to investigate its effect on other mechanical and physical properties with different concentrations.

REFERENCE

1- Perdigao J, Gomes G, Augusto V: The effect of dowel space on the bond strengths of fiber posts. J Prosth Dent 2007; 16:154-64.

2- Erdemir A, Ari H, Güngünes¸ H, Belli S: Effect of medications for root canal treatment on bonding to root canal dentin. J Endod 2004; 30:113-6.

3- Gomez M, Llido B, Rivero A, Rio J, Celemin A: A 10-year retrospective study of the survival rate of teeth restored with metal prefabricated posts versus cast metal posts and cores. J Dent 2010; 38:916–20.

4- Zarone F, Sorrentino R, Apicella D, Valentino B, Ferrari M, Aversa R, et al: Evaluation of the biomechanical behavior of maxillary central incisors restored by means of endo-crowns compared to a natural tooth: a 3D static linear finite elements analysis. Dent Mat J 2006; 22:1035–44.

5- Fernandes A, Shetty S, Coutinho I: Factors determining post selection: a literature review. J Prosth Dent 2003; 90:556–62.

6- Rasimick B, Wan J, Musikant B, Deutsch A: A review of failure modes in teeth restored with adhesively luted endodontic dowels. J Prosth 2010; 19:639–46.

7- Akkayan B, Gülmez T: Resistance to fracture of endodontically treated teeth restored with different post systems. J Prosth Dent 2002; 87:431-7.

8- Sahafi A, Peutzfeldt A, Asmussen E, Gotfredsen K: Bond strength of resin cement to dentin and to surface-treated posts of titanium alloy, glass fiber and zirconia. J Adhes Dent 2003; 5:153-62.

9- Galhano G, Valandro L, Melo R, Scotti R, Bottino M: Evaluation of the flexural strength of carbon fiber, quartz fiber, and glass fiber- based posts. J Endod 2005; 31:209-11.

10- Omiri M, Wahadni A: An ex vivo study of the effects of retained coronal dentine on the strength of teeth restored with composite core and different post and core systems. Int Endo J 2006; 39:890-9.

11- Santos P, Castro C, Silva G, Campos R, Soares C; Effects of post system and length on the strain and fracture resistance of root filled bovine teeth. IntEndod J 2008; 41:493-501.

12- Schwartz R: Adhesive dentistry and endodontics. Part 2: bonding in the root canal system-the promise and the problems: a review. J Endod 2006; 32:1125-34.

13- Tay F, Loushine R, Lambrechts P, Weller R, Pashley D: Geometric factors affecting dentin bonding in root canals: a theoretical modeling approach. J Endod 2005; 31:584-9.

14- Malyk Y, Kaaden C, Hickel R, Ilie N: Analysis of resin tags formation in root canal dentine: a cross sectional study. IntEndod J 2010; 43:47-56.

15- Boone K, Murchinson D, Schindler W, Walker W: Post retention: the effect of sequence of post space preparation, cementation time, and different sealers. J Endod 2001; 27:768–71.

16- Gu X, Mao C, Kern M: Effect of different irrigation on smear layer removal after post space preparation. J Endod 2009; 35:583–6.

17- Dietschi D, Duc O, Krejci I, Sadan A: Biomechanical considerations for the restoration of endodontically treated teeth: a systematic review of literature, Part II. Quint Int 2008; 39:117–29.

18- Cheng L, Weir M, Zhang K, Xu S, Chen Q, Zhou X, et al.: Antibacterial nanocomposite with calcium phosphate and quaternary ammonium. J Dent Res 2012; 91:460–66.

19- Morones J, Elechiguerra J, Camacho A, Holt K, Kouri J, Ramirez J, et al: The bactericidal effect of silver nanoparticles. Nanotechnology 2005; 16:2346-53.

20- Gale M, Darvell B: Thermal cycling procedures for laboratory testing of dental restorations. J Dentofac 1999; 27:89–99.

21- Fan C, Chu L, Rawls H, Norling B, Cardenas H, Whang K: Development of an antimicrobial resin- a pilot study. J Dent Mat 2011; 27:322–28.

22- Said H, Bakar W, Farea M, Husein A: The effect of different sealer placement techniques on sealing Ability: An in vitro study. J Conserv Dent 2012; 15:257-60.

23- Wachlarowicz A, Joyce A, Roberts S, Pashley D: Effect of endodontic irrigants on the shear bond strength of Epiphany sealer to dentin: J Endod 2007; 33:152-5.

24- Drummond J, Bapna M: Static and cyclic loading of fi ber-reinforce dental resin. Dent Mat J 2003; 19:226–31.

25- Plotino G, Grande N, Bedini R, Pameijer C, Somma F: Flexural properties of endodontic posts and human root dentin. Dent Mat J 2007; 23:1129–35.

26- Giachetti L, Russo D, Bertini F, Giuliani V: Translucent fi ber post cementation using a light-curing adhesive/ composite system: SEM analysis and pull-out test. J Dent 2004; 32:629–34.

27- Bitter K, Neumann K, Kielbassa A: Effects of pretreatment and thermocycling on bond strength of resin core materials to various fiber-reinforced composite posts. J Adh Dent 2008; 10:481–9.

28- Aleisa K, Ziad N, Rawda A, Charles J: Effect of luting agents on the tensile bond strength of glass fi ber posts: An in vitro study. J Prosth Dent 2013; 110:216-22.

29- Goracci C, Fabianelli A, Sadek F, Papacchini F, Tay F, Ferrari M: The contribution of friction to the dislocation resistance of bonded fi ber posts. J Endod 2005; 31:608–12.

30- Naumann M, Sterzenbach G, Rosentritt M, Beuer F, Frankenberger R: Is adhesive cementation of endodontic posts necessary? J Endod 2008;34:1006–10

31- Bonfante G, Kaizer O, Pegoraro L, Valle A: Tensile bond strength of glass fi ber posts luted with different cements. Braz Oral Res 2007; 21:159–64.

32- Schmitter M, Huy C, Ohlmann B, Gabbert O, Gilde H, Rammelsberg P: Fracture resistance of upper and lower incisors restored with glass fi ber reinforced posts. J Endod 2006; 32:328–30.

33- Nissan J, Dmitry Y, Assif D: The use of reinforced composite resin cement as compensation for reduced post length. J Prosthet Dent 2001;86:304–308

34- Salameh Z, Sorrentino R, Papacchini F, Ounsi H, Tashkandi E, Goracci C, Ferrari M: Fracture resistance and failure patterns of endodontically treated mandibular molars restored using resin composite with or without translucent glass fi ber posts. J Endod 2006; 32:752–55.

35- Monticelli F, Grandini S, Goracci C, Ferrari M: Clinical behavior of translucent-fi ber posts: a 2-year prospective study. Int J Prosthodont 2003; 16:593-6.

36- Bonfante E, Pegoraro L, Goes M, Carvalho R: SEM observation of the bond integrity of fi ber-reinforced composite posts cemented into root canals. Dent Mater 2008; 24: 483-91.

37- Marshall S, Bayne S, Baier R, Tomsia A, Marshall G: A review of adhesion science. Dent Mater 2010; 26:11-6.

38- Cury A, Goracci C, de Lima Navarro M, Carvalho R, Sadek F, Tay F, et al: Effect of hygroscopic expansion on the push-out resistance of glass ionomer-based cements used for the luting of glass fiber posts. J Endod 2006; 32:537-40.

39- Tay F, Pashley D: Monoblocks in root canals: a hypothetical or a tangible goal. J Endod 2007; 33:391-8.

40- Cheng Y, Zeiger D, Howarter J, Zhang X, Lin N, Antonucci J, et al: In situ formation of silver nanoparticles in photo cross linking polymers. J Bio Mat Res 2011; 97:124–31.

41- Cheng L, Zhang K, Melo M, Weir M, Zhou X, Xu H: Anti-biofi lm dentin primer with quaternary ammonium and silver nanoparticles. J Dent Res 2012; 91:598-04.

42- Chou C, Hsu S, Chang H, Tseng S, Lin H: Enhanced thermal and mechanical properties and biostability of polyurethane containing silver nanoparticles. PolymDegrad Stab. 2006; 91:1017-24.