Effects of Sonic Application of Adhesive Systems on Bonding Fiber Posts to Root Canals

Johanna Cuadros-Sanchez, DDS, Anna Szesz, DDS,* Viviane Hass, DDS, MS,* Rafael Tiago Patzlaff, MEng,† Alessandra Reis, DDS, PhD,* and Alessandro D. Loguercio, DDS, MS, PhD**

Abstract

Introduction: Luting posts inside the root canal is still a challenge because of the difficulty of bonding adhesive materials in the apical third of roots. This study evaluated the effect of the application mode of 3 simplified etch-and-rinse adhesives on the push-out bond strength (PBS), nanoleakage (NL), and *in situ* degree of conversion (DC) of fiber posts in the root canal. **Methods:** The roots of human premolars were endodontically prepared and divided into 6 groups according to the combination of the main factors: adhesive (Ambar, FGM, Joinville, SC, Brazil; Adper Single Bond 2, 3MESPE, St Paul, MN; and XP Bond+self-cure activator, DeTrey Dentsply, Konstanz, Germany) and application mode (manual or sonic). The posts were cemented and the PBS tested at 0.5 mm/min. The NL was evaluated by scanning electron microscopy after the immersion of specimens in 50% silver nitrate. Micro-Raman spectroscopy was used to measure the *in situ* DC. Root third was also considered in the statistical evaluation. Data were analyzed by 3-way repeated measures analysis of variance and Tukey tests (5%). **Results:** Under sonic application, the PBS and the *in situ* DC increased, whereas NL decreased significantly for all groups in the middle and apical thirds ($P < .05$). **Conclusions:** The application of simplified adhesives by sonic mode in the root canal is a feasible tool to increase the fiber post bond to root canals. *(J Endod 2014;40:1201–1205)*

Key Words

Bond strength, fiber posts, *in situ* degree of conversion, nanoleakage, post retention, resin cements, root dentin, sonic application

From the *Department of Restorative Dentistry, School of Dentistry, State University of Ponta Grossa, Paraná, Brazil; and †Department of Research and Development, Odeme Biotechnology, Joaçaba, Santa Catarina, Brazil.

Address requests for reprints to Dr Alessandro Dourado Loguercio, Universidade Estadual de Ponta Grossa–Mestrado em Odontologia, Rua Carlos Cavalcanti, 4748, Bloco M, Sala 64A–Uvaranas Ponta Grossa, Paraná, Brazil 84030-900. E-mail address: aloguercio@hotmail.com

0099-2399/$ - see front matter

http://dx.doi.org/10.1016/j.joen.2013.12.034

The cementation of fiber posts in endodontically treated canals results in restorations that resemble the natural dental structure because the modulus of elasticity of adhesive materials and fiber posts is similar to that of dentin (1, 2). However, a recent review of clinical studies showed that loss of retention is the major failure mode of fiber posts luted in root canals (1, 3, 4). The reduced visibility and access in the apical third, mainly without an operating microscope and limited moisture control after acid etching, are the probable reasons for the inadequate bonding, which occurs mainly in the most apical area (5). According to Breschi et al (6), several factors were found to negatively affect the adhesion of luting agents by altering dentine structure (7) or interfering with resin polymerization associated with the higher C factor inside the root canal (8).

Although several strategies have been suggested to improve the performance of adhesive systems (5, 6, 9), their results have been controversial, and they usually add more bonding steps or time to the clinical procedure. Recently, an *in vitro* study showed that application of the adhesive with a sonic device oscillating at 170 Hz improved the bond strength of adhesive systems to coronal dentin (10).

Although ultrasonic and sonic instruments are often used in different phases of endodontic treatment (11), to the best of our knowledge, these devices have not been used in adhesive procedures inside the root canal. Thus, the aim of the present study was to compare the push-out bond strength, nanoleakage, and *in situ* degree of conversion of simplified etch-and-rinse adhesives applied manually or with a sonic vibration device before fiber post cementation. The null hypothesis tested was that there would be no difference between manual and sonic application for any of the properties tested.

Materials and Methods

The Ethics Committee of the State University of Ponta Grossa approved this study (protocol # 268.529). Sixty-six extracted human maxillary premolars with a root length of 14 mm measured from the cementoenamel junction (CEJ) were used. The teeth were stored in distilled water at 4°C and were used within 6 months after extraction.

The teeth were sectioned transversely immediately below the CEJ using a low-speed diamond saw (Isomet 1000; Buehler, Lake Bluff, IL). After endodontic access, the working length was determined by inserting a #10 Flexofile (Dentsply Maillefer, Petrópolis, RJ, Brazil) into each canal until it was visible at the apical foramen and subtracting 1 mm from this length. The crown-down technique was used for instrumentation with Gates Glidden drills #2–#4 with apical enlargement to size 40 and .06 taper. After every change of instrument, the canal was irrigated alternately with 1 mL 1% sodium hypochlorite and 17% EDTA solutions. The roots were dried with paper points (Dentsply Maillefer) and filled with AH Plus (Denstply DeTrey, Konstanz, Germany), and tapered gutta-percha points were used with the vertical warm condensation technique. The root access was temporarily filled with a chemically polymerized glass ionomer cement (Maxxion R; FGM, Joinville, SC, Brazil), and the specimens were stored at 37°C in 100% humidity.

After 1 week, the gutta-percha was removed using Gates Glidden burs, leaving 4 mm of the apical seal, and the post space was prepared with a low-speed bur provided by the post manufacturer (FGM) to a fixed depth of 10 mm from the CEJ. The root canals were irrigated with 10 mL distilled water and dried with paper points.

At this point, the teeth were randomly divided into 6 groups (n = 11), resulting from the combination of the main factors: adhesive system/resin cement (Ambar/All Cem [FGM], Adper Single Bond 2/RelyX-ARC [3M ESPE], and self-polymerizing XP-Bond/Enforce [DeTrey Dentsply]) and application mode (manual or sonic).

In the manual application, the adhesives were applied inside the root canals with microbrushes (Vigodent, Rio de Janeiro, RJ, Brazil) according to the manufacturer's instructions. In the sonic groups, the same microbrush was attached to the tip of a prototype sonic applicator (which will be released on the dental market by FGM as Smart). The prototype produced an oscillating vibration of 10,200 rpm or 170 Hz measured by the Blackman-Harris sound method (12). The sonic device has 5 different oscillating frequencies (144.5, 150, 170, 223.5, and 167.5 Hz). The middle frequency (170 Hz) of the device (10) was used. It is important to report that the microbrush attached to the sonic device vibrates at the same oscillating frequency (170 Hz) of the device when in a noncontact condition. When the vibrating microbrush contacts the dentin surface, a reduction of this oscillating frequency may occur, which depends on the force exerted by the operator on the dentin surface. To avoid extreme variations, the operator should put the microbrush in contact with the root canal walls without much pressure.

Each resin cement was inserted with a Centrix syringe (DFL, Rio de Janeiro, RJ, Brazil), and the posts (DC 2, FGM; 13-mm length) were inserted immediately, and light polymerized for 40 seconds (Radii Cal; SDI, Baywater, Australia; 1.200 mW/cm^2). After storage in water at 37°C for 1 week, the specimens were sectioned perpendicular to the long axis into six 1-mm serial slices under water cooling (IsoMet 1000; Buehler, Lake Bluff, IL). Both sides of each slice were photographed with an optical microscope (Olympus Model BX 51; Olympus, Tokyo, Japan) at 40× magnification to measure the coronal and apical diameters of the posts in order to calculate the individual bonding areas (UTHSCSA ImageTool 3.0 Software; University of Texas Health Science Center, San Antonio, TX) as suggested by Mastoras et al (13).

The push-out test (PBS, n = 7 teeth) was performed in a universal testing machine at 0.5 mm/min, and the maximum failure load was calculated in MPa (14, 15). The failure mode was also evaluated by light microscopy and classified according to previously published studies (14–16).

For nanoleakage evaluation (NL, n = 2 teeth), the slices were immersed in 50 wt% ammoniacal silver nitrate solution for 48 hours, and the slices were photo developed to allow deposition of silver ions into metallic silver grains within voids along the bonded interface (17, 18). After polishing with up to 2500-grit silicon carbide paper, each slab was cleaned ultrasonically, air dried, mounted on stubs, and sputter coated with gold (MED 010; Balzers Union, Balzers, Liechtenstein). The resin-dentin interfaces were analyzed using a scanning electron microscope operated in the backscattered mode (SSX-550; Shimadzu, Tokyo, Japan). The relative percentage of NL at the bonded interface was measured in 4 regions of the slice (Fig. 1, 5 × 5 μm) of the bonded slab (medial, distal, vestibular and lingual) in a manner similar to that used in an earlier study (19).

The *in situ* degree of conversion (DC, n = 2 teeth) was measured with a micro-Raman spectrometer (Senterra; BrukerOptik GmbH, Ettlingen, Germany). After polishing and cleaning, each slice was placed on the microscope of the spectrometer. The micro-Raman spectrometer was first calibrated to zero and then for the coefficient values using a silicon sample. The following micro-Raman parameters were used: 20-mW neon laser with a 532-nm wavelength, spatial resolution of ≈3 μm, spectral resolution of ≈5 cm^{-1}, accumulation time of 30 seconds with 6 coadditions, and 100× magnification (Olympus UK, London, UK) to ≈1-μm beam diameter. In each slice, the spectra were taken in 4 areas of the intertubular hybrid layer as described for NL. For reference, the spectra of the unpolymerized adhesives were taken, and the *in situ* DC was calculated according to Wu et al (20).

Data of each test were evaluated by 3-way repeated measures analysis of variance (adhesive vs application mode vs root third) and the Tukey test (alpha = 5%).

Results

Three-way analysis of variance detected statistically significant differences in all tests (Table 1, P < .05). Under manual application, the PBS of the apical and cervical third showed the lowest and highest means, respectively, with the middle third showing an intermediate performance (P < .05). Under sonic application, the PBS values increased significantly mainly in the middle and apical thirds (P < .05).

Only a few cohesive fractures were observed in dentin. The most predominant failure pattern was adhesive (between dentin and resin cement) and mixed. No adhesive failures between the cement and post and cohesive failure of the post were observed (Table 1).

Under manual application, the apical third of all bonding agents showed the highest NL. Except for XP Bond/Enforce, the middle and cervical thirds (Fig. 2*A–F*, P < .05) of the adhesives exhibited the lowest NL. The use of sonic application significantly reduced the NL in all thirds irrespective of the bonding agent (Fig. 2, P > .05).

The apical third showed the lowest DC under manual application irrespective of the adhesive system. The cervical third showed the highest

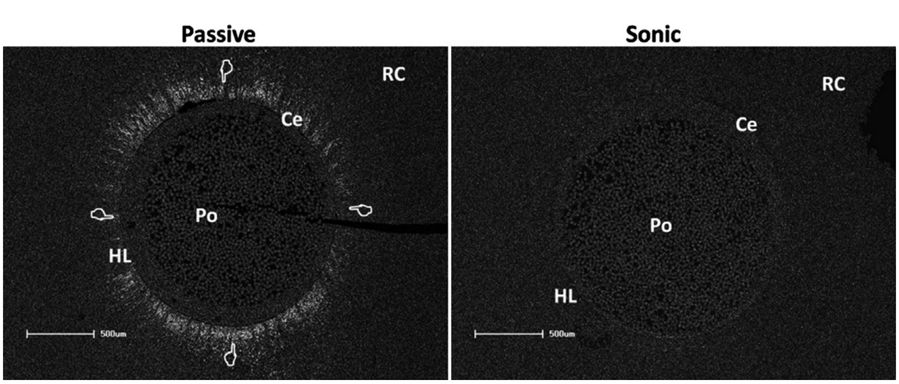

Figure 1. Representative scanning electron microscopic images of the post–cement–adhesive root interfaces bonded of XP Bond+self-activator/Enforce in the cervical third. The white hands indicate the regions where silver nitrate uptake was measured. When the adhesive was applied manually (passive), the amount of silver nitrate uptake was higher and occurred at all bonded interfaces. This was minimal with sonic application. Ce, resin cement; HL, hybrid layer; Po, fiber post; RC, root canal.