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Bond Degradation Resistance and Interface Characterization of a Water-Expandable Endodontic Obturation Point

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ABSTRACT

Aim: To evaluate the effect of different aging periods on the bond degradation resistance of the water-expandable endodontic obturation points/dentin interface.

Materials and Methods: Sixty freshly extracted human upper central incisors teeth were instrumented using a set of proTaper rotary instruments to achieve a size # 40 apical preparation. Irrigation was performed. The specimens were divided into two main equal groups of 30 roots each according to testing material. Each group was further divided into three subgroups according to aging period of 10 teeth each. Each subgroup was divided into three classes according to the root segment tested into coronal, middle, and apical segments. Single cone technique was used for both tested materials. The root canals were filled with C-Point ProTaper F4/Endosequence BC sealer and Protaper Universal Gutta Percha Points F4/AH-Plus sealer. After the storage period designated for each group, the samples were sectioned perpendicular to the longitudinal axis of each root into a series of 1.0 mm thick cross-sectional slices. Each root slice was tested for micro push-out bond strength. Interfacial analysis was done using Environmental Scanning Electron Microscopic. Results were tabulated and statistically analyzed using One-way ANOVA test followed by Tukey`s post hoc test for multiple comparison.

Results: At 4 hours and one month aging period there was a significant difference between the tested materials where the C-Point showed higher mean values.

Conclusions: The bonding quality during the initial setting period of C-Point/Endosequence obturating system was not affected and didn't deteriorate with aging; however C-Point/Endosequence obturating system performed better than Gutta-Percha/AH-Plus.

KEYWORDS

C-Points; Endosequence Bc Sealer; Gutta Percha Points; Ah-Plus Sealer; Micro Push-Out Bond Strength Test.

INTRODUCTION

In root canal treatment, complete sealing of the root canal system after cleaning and shaping is critical to prevent oral pathogens from colonizing and re-infecting the root and periapical tissues. Although gutta-percha is the most commonly used root canal filling material and considered the gold standard root canal filling material, it does not fulfil all the properties of an ideal root canal filling as it does not bond to the internal tooth structure, which results in the absence of a complete seal leading to leakage that take place at the interface between the sealer and gutta-percha or the sealer and dentin

Economides et al. [1]. Finding a gutta-percha substitute that would provide a superior seal of the root canal system has become a challenge in modern endodontics.

New obturation materials have been introduced over the past decade to improve the seal of the root canal system. However, it is not clear whether they have really produced a three-dimensional impervious seal that is important for reducing diseases associated with root canal treatment. The C-Point; a component of a Self-Sealing Obturation System is made from contact lens plastic Endo-Technologies, LLC, Shrewsbury, MA [2]. Once placed in the canal with the accompanying bioceramic sealer, the C-Point uses dentinal moisture to radially expand and seal the root canal laterally. C-Points have a 2-component design, with a central core to provide good handling characteristics and a hydrophilic polymer coating, which radially expands to seal the canal.

Bond strength has been measured using conventional tensile tests on external root dentin or on the root canal dentin surface with the pull-out and the push-out methods Gesi et al. [3], Skidmore et al. [4], Ungor et al. [5]. The push-out test provides a better evaluation of the bonding strength than the conventional shear test for parallel-sided samples. It has the benefit of closely simulating clinical conditions Drummond et al. [6].

To date, there has been no direct comparison of the effect of lateral expansion capability of C-Point with that of gutta-percha, the most widely used root filling material, in the presence of a water-containing environment. Water ingress can cause hydrolysis and plasticizing of the resin components. Plasticization is a process in which fluids are absorbed by the resins, causing them to swell, resulting in degradation of their mechanical properties Archegas et al. [7]. Thus, the objective of the present study was to examine the effect of different aging periods at simulated physiologic temperature on the bond degradation resistance of the water-expandable endodontic obturation points/dentin interface. The null hypothesis was that the micro push-out bond strength was the same for both root canal obturation systems.

MATERIALS AND METHODS

Materials (Table 1)

1. Water expandable root canal obturating system: C-Point: Obturation point / Endo-sequence BC Sealer: Bioceramic sealer.

2. ProTaper Universal Gutta-Percha Points: Root canal filling material / AH-Plus: Epoxy resin based sealer.

Table 1: Materials' Specifications, Composition, Manufacturers and Batch Numbers.

Materials	Specification	Composition	Manufacturer	Batch no.
C-Point	Water-expandable endodontic obturation point	Central Core: Combination of two proprietary nylon polymers, Trogamid T and Trogamid CX. Outer Polymer Layer: A cross-linked copolymer of acrylonitrile and vinylpyrrolidone, which has been cross-linked using allyl methacrylate and a thermal Initiator	Endo Technologies, LLC, Shrewsbury, MA,USA	P050313-1Z
Endo Sequence BC Sealer	Bioceramic sealer	Zirconium oxide, Calcium silicates, Calcium phosphate monobasic, Calcium hydroxide, ¬Filler and Thickening agents	BSavannah, GA 31419	165893
Protaper Universal Gutta-Percha Points	Root canal filling material	Polyester, Difunctional methacrylate resin, Bioactive glass, Bismuth oxychloride, Barium sulfate, Coloring agent, Polyterpene; a polymer of isoprene	Dentsply DETray GmbH. Str 1.D-78467. Kanstanz. New York, PA, USA	162850
AH-Plus	Epoxy resin based sealer	Epoxide paste: Diepoxide, Calcium tungstate. Zirconium oxide, Aerosil, pigment. Amine paste: Adamantane Amine,N'dibenzyl.5oxa onandiamine, 9 TCD Diamine, Calcium tungstate Zirconium oxide, Aerosil Silicone oil		1405000907

METHODS

Teeth selection

Sixty freshly extracted human upper central incisors teeth with straight root canal, fully developed apices and free of cracks, caries or fractures and had no previous root canal treatment were selected. The selected teeth had similar root length of 12 mm. Teeth were thoroughly washed, scrubbed and scaled to remove blood, mucous, shreds of periodontal ligament, and calculus. The teeth were examined using magnification lens of ×7 to exclude any tooth with cracks or structural defects. Teeth were stored in 1% chloramine-T at 4°C, and used within

1 month after extraction Sirisha et al. [8].

Preparation of teeth (Root Canal Preparation)

After gaining access to the root canal, apical patency was verified with a size 15 K-file that was inserted into the root canal until the tip was just visible beyond the apex. Working length was determined by subtracting 1 mm from that length. Canals were shaped using nickel-titanium rotary instruments ProTaper (Dentsply-Maillefer, Ballaigues, Switzerland) following the manufacturer's instructions (ProTaper Universal Guidelines; Dentsply, Maillefer, 2008). Root canals were prepared according to the sequence: SX, S1, S2, F1, F2, F3 and F4 files. All teeth were instrumented with a crown-down technique. All shaping files (SX, S1, and S2) were used in a brushing motion. All finishing files (F1, F2, F3 and F4) were withdrawn from the root as soon as they reached the full working length for one time Harty and Ford [9].

Irrigation was performed using 3 mL of 2.5% NaOCl after every change of instrument. Following biomechanical preparation 17% EDTA (Pulpdent Corporation, Watertown, MA, USA) was used for 1 min, followed by distilled water for 1 minute. The root canals were dried with paper points before filling Takeda et al., [10] and Shokouhinejad et al. [11].

Grouping of Samples

The teeth were divided into two main equal groups (A) of 30 teeth each according to testing the obturating material as follows; in the first group (A1) roots were obturated with C-Point / Endsequence bioceramic sealer, in the second group (A2) roots were obturated with Gutta-Percha / AH-Plus Epoxy resin based sealer. Each group was further divided into three subgroups of 10 roots each according to the testing period (T); (T1) after four hours, (T2) one day, and (T3) after one month. Each subgroup was divided into three classes (S) according to the root segment tested into (S1) coronal, (S2) middle, and (S3) apical segments.

Obturation Techniques

Single cone technique was used for both groups. Group (A1); the root canals were filled with C-Point ProTaper F4 and Endosequence BC sealer (Table 1). The point was trial-fitted to achieve tug-back Bindslev et al. [12]. A Radiograph was taken to confirm the position of the point. Endosequence BC sealer was used according to the manufacturer's instructions. The sealer is supplied in as a paste in a syringe with different intra-canal tips. The intra-canal tip was securely attached with a clockwise twist to the hub of the syringe. It was then inserted into the canal not deeper than the coronal one third. A small amount (1-2 calibration markings) of the sealer was introduced into the root canal by compressing the plunger of the syringe. The sealer was spread on the canal walls using a #15 hand K-file. The cone was coated with a thin layer of sealer and inserted slowly into the canal. The C-point was trimmed to the level of the canal orifice using a high speed handpiece and a cylindrical diamond stone.

Group (A2); the root canals were filled with ProTaper Universal Gutta-Percha Points F4 and AH-Plus sealer. The gutta-percha cone was coated with AH-Plus sealer and inserted into the root canal to the working length. The excess point was then cut with a heated instrument. After filling the root canals of all teeth, a temporary filling material (Cavit, 3 M, ESPE, and St. Paul, USA) was used to fill the access cavities Badami and Ahuja [13].

Incubating Storage Container

A ready-made plastic container with a lid was used for storage of the teeth during the aging periods. To simulate the oral environmental condition through the different testing periods an opening was made in the lid to receive a digital temperature control unit to control the water temperature (37°C ± 0.1°C).

Teeth Storage

The teeth were mounted to tubes through plastic hoses surrounding the root. The tubes were connected together in groups forming straight rows and fixed together to a plastic base that lies on the bottom of the plastic container. Each row represented test group (Figure 1A). The tube system used in the experiment had two directions of liquid flow; one horizontal with two opening for inter-connection of the extensions, and the other direction perpendicular to it with three opening for mounting of the teeth (Figure 1B).

Figure 1: (A) Pipeline system.

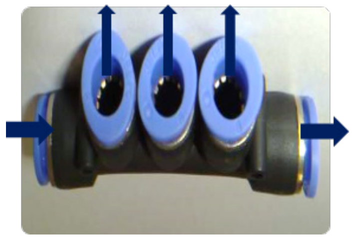

Figure 1: (B) Pipeline unit.

The container was filled by distilled water which was renewed every week (Figure 2). Water level was kept below the ceme-to-enamel junction by 2 mm to insure hydration of the tooth structure over the aging periods of 4 hours, one day and one month Grossman and Schafer et al. [14, 15] at the same time no water can pass through the canal from its coronal end Hassan [16].

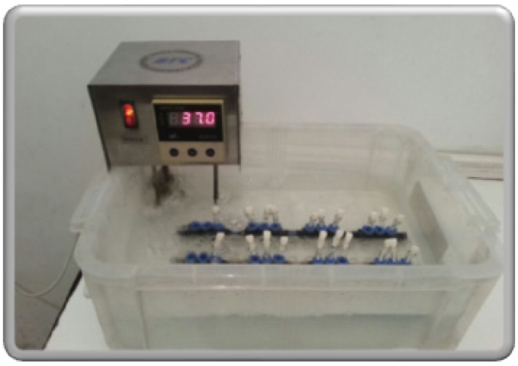

Figure 2: The incubation storage box open and the teeth mounted on the pipeline system.

Preparation of root slices for micro push-out test

Each tooth was then removed free from its holding hose after the specific aging period of the test. Each tooth from specific class were mounted in an especially designed rectangular Teflon molds made of polymethyl-methacrylate (PMMA) resin blocks of 4 cm length X 2 cm width X 3 cm height, so that the crowns were upside down inside the mold.

Each specimen was gripped by the attachment jig of the cutting machine to prepare root slices. The samples were sectioned perpendicular to the longitudinal axis of each root into a series of cross-sectional slices. The apical 1 mm of each root was discarded. Two successive dentin disk slices were obtained from each root segment using a water-cooled precision diamond disc of 4-inch diameter x 0.5 mm thickness under continuous water spray with flow rate of 0.7 gal / min [3 liter/min] cooling system (Isomet Buehler 500, Lake Bluff, IL, USA).

The thickness of each slice was (1 mm) and verified using a digital caliper (Standard Digital Caliper ALORA. Germany). The exact dimensions of each disk were within ± 0.10 mm. A custom-made loading fixture [metallic block with circular cavity at the middle, this cavity for specimen housing having a central whole to facilitate displacement of extruded filling material. Similarly, multiple cylindrical fabricated stainless steel plunger with different diameter that provided the most extended coverage over the filling material without touching the canal wall, of 1.0, 0.76, 0.50, and 0.35 mm to avoid any interference owing to any root canal taper.

Each slice was marked on its coronal side with an indelible marker for sample positioning so that the push-out force is applied from the apical to the coronal side of each disc. Each root slice was mounted in, then subjected to compressive loading at a crosshead speed of 0.5 mm/min via a computer controlled materials testing machine (Instron Universal testing machine) until debonding occurred.

To express the bond strength in Mega Pascals (MPa), the load at which failure occurred was recorded in newtons (N) and then was divided by the interfacial area. The radii of the coronal (r2) and apical aspects (r1) of each slice were measured from digitized images, using image analysis software (Image 4.01, Scion Corp., Frederick, MA).

The interfacial area (mm2) was calculated by (π r1 + π r2) x L

L was calculated from √((r1-r2)^(2)+h^2) ,

where π is the constant 3.14,

r1 is the smaller radius,

r2 is the larger,

and h is the thickness of the section in mm Filho et al. [17].

Statistical analysis

Data was presented as mean and standard deviation (SD) values. Normality test was performed by Shapiro-Wilk and Kolomograf - Smirnov test, which revealed that the data was non-parametric data at P ≤ 0.05. Statistical analysis was performed with SPSS 16.0®.

I. Results of Micro push-out bond strength test: Gutta-percha/AH-Plus group: Table (2)

Table 2: Effect of Aging Periods on the Micro Push-Out Bond Strength Values of the Tested Root Segments Filled with Gutta-Percha/AH-Plus and Comparison Between the Different Root Segments at the Same Aging Period.

Aging Periods	Coronal		Middle		Apical		P-value
	Mean	SD	Mean	SD	Mean	SD	
4 Hours	0.69[a]	0.69	0.53[a]	0.34	0.34[a]	0.21	0.735 NS
1 Day	2.58[b]	1.43	0.89[b]	0.96	1.60[b]	0.80	≤0.001*
1 Month	0.97[c]	0.64	0.92[b]	0.28	2.04[c]	1.54	0.002*
P-value	0.001*		0.134 *NS*		0.001*		

*Significant difference **Highly Significant NS: non-significant Means with same letter are insignificant different in the same column.

C-Point/Endosequence group: Table (3)

There was significant difference between the mean micro push-out bond strength values of the different aging periods in the coronal segments. One day period showed the highest mean value followed by one month. 4 hours showed the lowest mean bond strength values. The tested middle segments showed that there was non-significant difference between one day and one month, where they showed the highest mean values. Both one day and one month showed significant difference with the 4 hours aging period which scored the lowest mean value.

Concerning the apical segments, there was significant difference between all aging periods where one month showed the highest mean value followed by the one day and 4 hours respectively.

Comparison between the micro push-out bond strength of different root segments at the same aging period. In the 4 hours aging period there was non-significant difference between the mean micro push-out bond strength values of all the segments. Concerning the one day aging period, there was significant difference between all tested segments where the coronal segment showed the highest mean value followed by apical segment and middle segment respectively. At one month aging period, there was significant difference between the mean micro push-out bond strength values of the different root segments tested. The apical root segment showed the highest mean value followed by coronal segment. Middle segment showed the lowest mean value.

C-Point/Endosequence group: Table (3)

Table 3: Effect of aging periods on the micro push-out bond strength values of the tested root segments filled with C-Point/ Endosequence and comparison between the different root segments at the same aging period.

Aging Periods	Coronal		Middle		Apical		P-value
	Mean	SD	Mean	SD	Mean	SD	
4 Hours	1.63[a]	0.80	0.80[a]	1.49	9.91[a]	3.18	≤0.001*
1 Day	2.77[b]	1.50	3.50[b]	1.90	2.30[b]	1.60	0.102 NS
1 Month	0.55[c]	0.23	1.56c	0.86	4.64[c]	1.96	≤0.001*
P-value	0.001*		0.001*		0.001*		

There was significant difference in the mean micro push-out bond strength values between different aging periods in the coronal segments. One day aging period showed the highest mean value followed by 4 hours, while one month showed the lowest mean value. The tested middle segments showed that there was significant difference between all aging periods, with the highest mean value found at one day aging period followed by that of one month aging period and the lowest mean value was scored at 4 hours aging period. Regarding the apical segments, there was a significant difference between all aging periods where 4 hours showed the highest mean value followed by the one month and one day respectively.

Comparison between the micro push-out bond strength of different root segments in the same aging period There was a significant difference between the mean micro push bond strength values of the different segments tested after 4 hours aging period where the apical segment showed the highest mean value, followed by the coronal segment followed by the middle segment which scored the lowest mean value. Concerning the 1 day aging period, there was non-significant difference between all tested segments. There was significant difference between the mean micro push bond strength values of the different root segments tested at 1 month aging period. The apical root segment showed the highest mean value followed by middle segment. Coronal segment showed the lowest mean value (Figure 3).

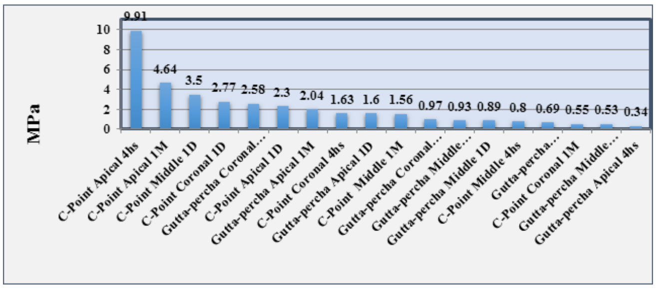

Figure 3: Bar Chart representing the micro push-out bond strength means values of tested materials ranked from higher to lower.

DISCUSSION

C-points contain a hydrophilic polymer coating around a central core. This coating can absorb water from the root canal and swell laterally only to any open space leading to self-sealing Economides et al. [1]. Though gutta-percha is commonly used as an endodontic obturation point, its ability to laterally seal the root canal dentin remains questionable. C-point has a two-component design, a central core to provide good handling characteristics and a hydrophilic polymer coating, which radially expands to seal the canal. C-point is designed to expand laterally without expanding axially, by absorbing residual water from the instrumented canal space and from naturally-occurring intraradicular moisture Hegde and Arora [19]. When hydrated in the root canal, C-points expand, conforming to the canal irregularities and pressing the companion hydrophilic sealer into concavities, lateral portals of exit and dentinal tubules of the root canal Jayasenthil et al [20].

Endosequence is a premixed bioceramic endodontic sealer that is composed of zirconium oxide, calcium silicates, calcium phosphate monobasic, calcium hydroxide, filler, and thickening agents. Therefore, unlike conventional base/catalyst sealers, BC Sealer utilizes the moisture naturally present in the dentinal tubules to initiate its setting reaction. Additionally, it has a similar composition to white mineral trioxide aggregate (MTA) and has shown excellent physical properties and antimicrobial activity.

Aging of specimens

Specimens were aged for 4 hours, one day and one month. To assess long-term effectiveness, it is crucial that one first determine the short-term bonding effectiveness. The first aging period for testing was 4 hours which was considered as the baseline data to which the other aging periods were compared

Paque and Sirtes [21]. 4 hours testing period was selected as it was reported that the setting time of Endosequence BC Sealer is 4 hours which may be exceeded in overly dry canals. An early union between the sealer with both the dentin of the canal wall and the core material in the same time is required as it act like a binding agent between the core material and the root canal dentin.

AH-Plus has better penetration into the micro-irregularities because of its creep capacity and long setting time of 8 hours, which increases the mechanical interlocking between sealer and root dentin Shokouhinejad et al. [11].

Micro-push out (μPO) test is a modification of push out test where the specimen thickness is less than or equal to 1 mm2. The results of the tested aging periods on the micro push-out bond strength values of teeth obturated with Gutta-percha/AH-Plus revealed that 4 hours testing period had a significant negative effect on the bond strength; where the one day and one month aging periods showed statistically significantly higher mean push-out bond strength values than that of 4 hours testing period in all tested segments Table (2). There was also non-significant difference between the tested segments at 4 hours.

It was expected that the bond strength of Gutta-Percha/AH-Plus will be affected when testing it after 4 hours only since the manufacturer's instructions of use for AH-Plus TM, states the cements have 8 hours (480 min) setting time. ANSI/ADA (2000) requirements require that the setting time of a sealer shall be within 10% of that stated by the manufacturer.

Decreasing the bond strength values at one month testing period over one day with significant effect in the coronal and middle segments might be related to the inability of the gutta-percha to reinforce endodontically treated tooth. Gutta-percha also does not chemically bond to the dentin wall to compose the monoblock system desired for tooth reinforcement. According to Teixeira et al. [23]. Gutta-percha does not from a monoblock even with the utilization of a resin-based sealer such as AH-Plus, because the sealer does not bind to Gutta-percha. Moreover, due to the hydrophobic nature of the Gutta-percha cones the sealer tends to pull away from the Gutta-percha on setting. Numerous in vitro studies have shown that Gutta-percha obturated teeth leak at high rates Paul et al. [24], Prado et al. [25].

The results of the effect of aging periods on the micro push-out bond strength values of the tested root segments filled with C-Point/Endosequence Table (3) revealed that one day results were significant than the 4 hours testing period. The hydrophilic nature of both the point and the sealer can explain the improvement in the bond strength with time. The polymer coating of the C-point is designed to expand by absorbing residual water from the instrumented canal space and from naturally-occurring intraradicular moisture Hegde and Arora [19]. This non-isotropic lateral expansion was said to enhance the sealing ability of the root canal filling, thereby reducing the possibility of reinfection and potentiating the long-term success of root canal treatment. Similarly, the hydrophilic nature of the Endosequence bioceramic sealer allowed the C-point to hydrate and swell to fill any voids. It also forms a nano-composite network of gel-like calcium silicate hydrate intimately mixed with hydroxyapatite, and forms a hermetic seal when applied inside the root canal. Furthermore, it produces calcium hydroxide and hydroxyapatite as by-products of the setting reaction. The manufacturer also claims that the addition of bioceramics gives the sealer exceptional dimensional stability and makes it non-resorbable inside the root canal Badami and Ahuja [13].

These micro push-out bond strength values were found in both coronal and middle segments, where the bond strength was higher after one day than after 4 hours. Although C-Point is technically a single-cone obturation technique, this product utilizes the principle of hygroscopic expansion of the in-situ point to fill these anatomical gaps, and potentially provide a better seal.

The apical segment has different manner as the bond strength was higher at 4 hours testing period and start to decrease significantly after one day and one month. This alteration could be clarified by the effect of water sorption suffered by the hydrophilic polymer coating. Water sorption in polymeric materials is a diffusion-controlled process and affected mainly by the amount of water absorbed by the fluid pressure capacity of the tissues apically Paque and Sirtes [21]. In addition to, variation in the root canal anatomy creates difficulty in three dimensional obturation of the canal space, and may contribute to endodontic failure. Root canals have different cross-sectional shape, with some being oval, which render them difficult to obturate. In the current study leakage increased from the time laps between one day and one month. Studies indicate single-cone obturation methods to be inferior in their ability to achieve a fluid-tight seal Bindslev et al. [12].

In the current study, root canals were prepared using the ProTaper Universal System according to the sequence: SX, S1, S2, F1, F2, F3 and F4 files and were filled with ProTaper Universal Gutta Percha Points F4 C-Point ProTaper F4. According to Ingle and Bakland [26] the cross-section of the maxillary central incisor at the cervical level is slightly ovoid, at the mid-root it is ovoid to round and at the apical third level the canal is round. The oval shaped canals cause increase in the sealer thickness which adversely affects the bond strength mean value of the coronal segments filled with C-Point/Endosequence BC Sealer tested after one day and one month testing period.

This result was contradicted by Didato et al. [27] where they claimed that the lateral expansion of C-point occurs non-uniformly, with the expandability depending on the extent to which the hydrophilic polymer is pre-stressed i.e., contact with a canal wall will reduce the rate or extent of polymer expansion. This non-isotropic lateral expansion is said to enhance the sealing ability of the root canal filling, thereby reducing the possibility of reinfection and potentiating the long-term success of root canal treatment.

The result was also contradicted by Carneiro et al. [28] regarding the root thirds, the highest bond strength was obtained in the coronal third compared with the middle and apical thirds, whilst Babb et al. [29], found no significant difference between the root thirds. One of the factors that could explain the different bond strengths between the root thirds is the different internal anatomy of the canals at each third owing to the variation in the number and diameter of the dentinal tubules. On the other hand, according to Babb et al. [29] the variations in tubular density along the canal are insufficient to alter sealer adhesion.

Comparison between Gutta-Percha/AH-Plus and C-Point/Endosequence in respect to bond strength revealed that C-Point/Endosequence performed better than Gutta-Percha/AH-Plus with highly significant difference especially in the middle and apical segments at all testing periods. The delayed setting time (4–10 hours) and the hydrophilic nature, allowed the C-Point to hydrate and swell to fill any voids.

Tyagi et al. [30] reviewed the evolution of root canal sealers and stated that conventional retreatment techniques are not able to fully remove Bioceramic sealer. High alkalinity (pH 12.8) also increases its mineralization process. The hydrophilic nature of the sealer is similar to the points used, consequently root canal hydration aids in the formation of calcium phosphate hence gives strength. Low contact angle allows it to spread easily over the dentin walls of the root canal and to get inside and fill the lateral micro canals. This bioceramic sealer also forms chemical bond with the canal's dentin walls, which is why no space is left between the sealer and dentin walls. Bioceramic sealer does not shrink upon setting. In fact, they actually expand slightly upon completion of the setting process.

The micro push-out bond strength results were in agreement with that of Pawar et al. [31], were the novel filling method using a single C-Point and BC sealer increased the bond strength compared with the traditional method using gutta-percha and AH-Plus sealer. They believed that the hydrophilic nature of the sealer might have potentially resulted in more intimate contact with the canal walls than the hydrophobic AH-Plus sealer. Furthermore, it could be assumed that the slow-setting of the BC sealer combined with the slow expansion of the C-Point when exposed to moisture may have potentially pushed the sealer into places that lateral compaction where the AH-Plus sealer could not reach.

This result was in conflict with that of Economides et al. [1]. It is supposed that materials subjected to post-setting expansion are assumed to exhibit favorable sealing and adhesive properties, since expansion increases the movement of the material to fill voids and gaps between the main cone and the root canal walls and permits flow into canal irregularities to fill lateral canals and apical deltas. However, this theoretic advantage is not reflected in terms of bond strength in the results from his study where no significant differences were found between the mean bond strength of root canals filled with the Smartseal system and the root canals filled with gutta-percha and AH-26 at either level of sectioning. These results indicate that the adhesion of Smartseal to dentin is similar to that of a sealer combined with gutta-percha used either in the lateral condensation or in the single cone technique.

Moreover, the results were in disagreement with Carvalho et al. [32], who evaluated the dentin bond strength of Endo-Sequence BC Sealer and AH-Plus sealer without points using mandibular premolars prepared with ProTaper System. Hollow roots were sectioned to obtain 4 slices of 1.5mm thickness each. Each hollow slice was then filled with one of the sealers and compressed between a glass slide and a mylar matrix and stored for 30 days. The AH-Plus sealer presented significantly higher micro push-out bond strength to dentin, than EndoSequence BC Sealer ($p < 0.05$). The difference of results might be related to the use of the sealer only without a core material.

CONCLUSIONS

Under the limits of the present study it was concluded that the bonding quality during the initial setting period of C-Point/Endosequence obturating system was not affected and didn't deteriorate while improved with aging. Both tested obturating systems had good bond strength with aging; however, C-Point/Endosequence obturating system performed better than Gutta-Percha/AH-Plus. Aging time has an apparent influence on the bond performance of both tested obturating systems to dentin. Position of the root segments has influence on its performance in the different aging periods.

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