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## Comparative *in vitro* Study of the Bond Strength on Dentin of Two Sealing Cements: BC-SEALER and AH-PLUS

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### ABSTRACT

Gutta-percha with a sealer cement has been used for many years as a fill for root canal therapies, new materials and techniques have been recently developed that could increase the success rate of endodontic treatments. It is important to compare materials that are used today, with those that are coming to the market, which possess considerable advantages that may well increase the rate of successful treatments. The purpose of this research is to evaluate the adhesion properties of a new bioceramic sealer: EndoSequence® BC Sealer<sup>TM</sup> using BC Points. For this, the following techniques were used: Single cone obturation and lateral condensation with AH-Plus. The results demonstrated differences between the groups of AH-Plus and BC-Sealer. On the bond strength that was applied in the different thirds of the root canal, the sealer cement BC-Sealer proved to be the best adhesion material in all thirds of the root canal being significantly more noticeable in the apical third. The two sealants are effective root canal adhesives, used properly, any of them may grant an acceptable result.

**Keywords:** bond strength, comparative study, sealing cements.

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## RESUMEN

A pesar de que la gutapercha con cemento sellador ha sido utilizada durante muchos años, últimamente se han desarrollado nuevos materiales y técnicas que podrían incrementar la tasa de éxito en los tratamientos endodónticos. Es importante comparar materiales que en la actualidad se utilizan con los nuevos que están saliendo al mercado con considerables ventajas que puedan así aumentar el índice de tratamientos exitosos. Por lo tanto, el propósito de esta investigación es evaluar las propiedades de adhesión de un nuevo sellador biocerámico Endo-Sequence® BC Sealer<sup>TM</sup> usando BC Points. Para esto, se utilizó la técnica de obturación cono único y condensación lateral con AH-Plus. Se encontraron diferencias entre los grupos de AH-Plus y BC-Sealer. Sobre la fuerza de adhesión que se aplicó en los diferentes tercios del conducto radicular, el cemento sellador BC-Sealer demostró ser el material con mejor adhesión en todos los tercios del conducto radicular siendo significativamente más notable en tercio apical. Los dos cementos selladores son efectivos para la adhesión en los conductos radiculares, cualquiera de estos bien utilizados otorgará un resultado aceptable.

**Palabras clave:** cementos selladores, estudio comparativo, fuerza de adhesión.

## INTRODUCTION

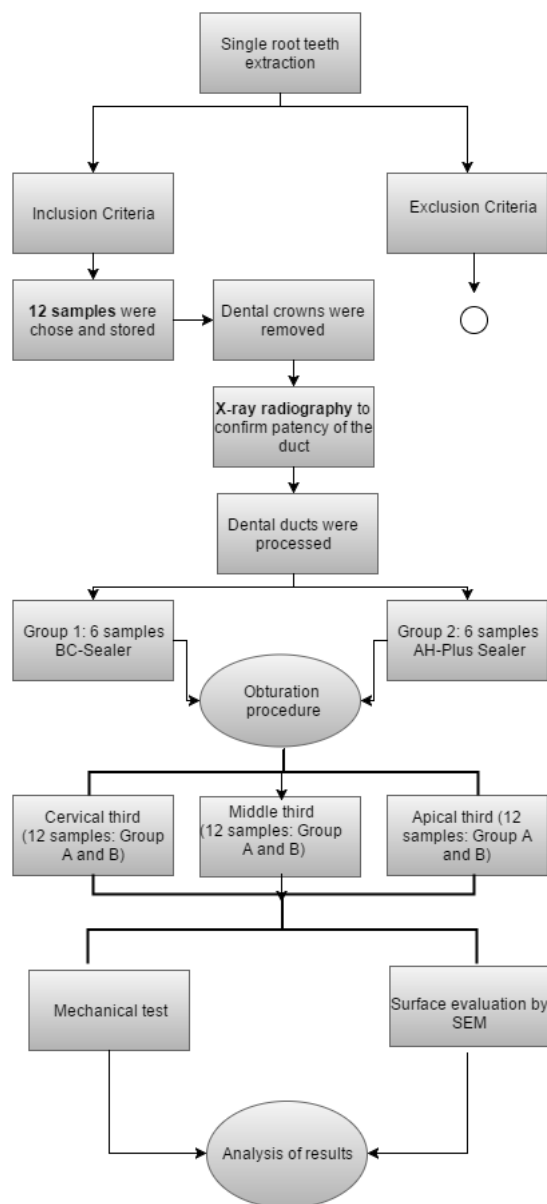
One of the keys to successful the success of root canal therapy is an appropriate obturation [1]. The sealing of the duct system has been historically achieved with gutta-percha and cement [2]. The purpose of the obturation is to provide a filling to the duct in all aspects in order to create an apical seal to the fluids to avoid the entry of bacteria and their toxins in the periapical tissues [3]. A suitable and properly implemented 3D obturation of the root canal is a vital step towards a successful endodontic therapy. It has been argued that a successful treatment of the conduits depends on its preparation and biomechanical cleaning, in addition to the tridimensional obturation of the conduit system, that is, the complete sealing of the space occupied by the pulp tissue. The technique of lateral condensation has been the most used for the filling of the root canal and serves as a reference for the evaluation of other techniques [4].

Other study has shown that BC sealer eliminated all bacteria within two minutes of contact. The authors explained that

its potent antibacterial effect might be a combination of its high pH, hydrophilic nature and active dissemination of calcium hydroxide [5]. The hardening of the sealeing occurs in a three or four hour's lapse, which gives the handler enough time to use it in surgical and non-surgical applications [6]. In addition, sealability of the BC sealer with single cone technique has been compared against the AH Plus with the vertical technique. That study concluded that there was no difference in the sealability of each material with the previously mentioned techniques [7, 8].

Subsequently, a study evaluated the adhesion capability of two sealing cements, namely MTA Fillapex and AH-plus. In this study, 40 premolars which were prepared biomechanically with a rotary instrument were used, and all the roots were sealed only with cement sealer without using gutta-percha. The results showed that AH-Plus has greater adhesion than the MTA Fillapex [9].

Finally, the adhesion forces of the MTA Plus sealer (Avalon Biomed Inc) and the BC EndoSequence sealer (Brasseler) were evaluated when used with the thermoplastic



**Figure 1.** General methodology.

and single cone techniques. Fifty single-rooted teeth from humans were divided randomly into 5 groups ( $n = 10$ ). Among the results obtained, the MTA-CW Plus had the lowest bond strength of all the groups. The BC-SC group had superior adhesion strength than the MTA Plus-SC and AH-CW Plus. No significant differences were observed among the other groups [10]. This study was based on comparing *in vitro* bond strength on dentin of the two sealing cements: BC-SEALER and AH-PLUS.

## METODOLOGY

The methodology followed to evaluate the mechanical properties of the sealants is shown in figure 1.

### Samples

Single-rooted teeth were extracted from patients who attended the faculty's clinic (figure 2); the patients went to the clinic because they needed a teeth extraction procedure. After that, the samples were collected and stored, but not extracted for research purposes. These teeth were selected using the following inclusion criteria: Permanent human teeth that were recently extracted, uniradicular with wide and rectal roots and with a mature apical. In addition, the following exclusion criteria were used: teeth with calcified canals, with internal and external resorption and with apical curvatures.

The EndoSequence BC Sealer is a premixed ready-to-use injectable bioceramic cement paste, an insoluble, radiopaque and an aluminum-free material based on a calcium silicate composition, which requires the presence of water to set and harden. This sealer is chemical composed by zirconium oxide, calcium silicates, monobasic calcium phosphate, calcium hydroxide, filler and thickening agents.



**Figure 2.** Single root teeth chosen.

On the other hand, AH Plus sealer consists of a paste-paste system, which is delivered in two tubes and in a new double barrel syringe. AH Plus is characterized by very good mechanical properties, high radio opacity, little polymerization shrinkage, low solubility, and, not least, a high degree of stability on storage. The chemical composition of the AH plus sealer possess the following components: Epoxide paste amine paste, diepoxide, calcium tungstate, zirconium oxide, aerosol, pigment, 1-adamantane amine, N, N'-dibenzyl-5-oxanonandiamine-1,9, TCD-diamine and silicone oil.

Twelve single-rooted extracted teeth were used with large and straight passages for evaluation; the samples were stored in chloramine-T solution at room temperature. Then, the clinical crowns of the dental organs were removed with a diamond disc (Brasseler) at low speed, and then were standardized to a 14 mm of length. An X-ray radiography was initially taken and limes type K # 10 (SybronEndo) were used to confirm patency of the duct, and then X-Ray radiographies were taken with the handpiece type k # 15 (SybronEndo). At the radiograph's obtained were applied a real working length of a 1 mm short of the radiographic apex. The ducts were instrumented by a single operator using rotary instruments with a nickel-titanium TF adaptative to 50 /.04, 23 mm (SybronEndo). For this, navitip needle of 17 mm and 30 gauge (Ultradent) was used to irrigate between each instrument. The Irrigation was performed out with a sodium hypochlorite solution (NaOCl) at 5.25%, and wrapped between each instrument, with a lime type K # 15 (Sybro-Nendo), then NaOCl was ultrasonicated for 3 cycles of 20 s at the end of the instrumentation.

All experimental groups were irrigated with 3 ml of EDTA Smear Clear at 17% (SybronEndo) and subsequently, the chelating agent was exposed to ultrasound with a VARIOS 350 (NSK) equipment, with

a support for limes U type 120 or (NSK) and U type limes # 20 (NSK) with 3 cycles of 20 s, then each sample received a final irrigation with 5 ml solution of 5.25% NaO. Ducts were dried with paper points # 50 (SybronEndo).

The twelve samples were randomly divided to make 2 groups of 6, Group 1: was filled with BC Sealer<sup>TM</sup> single cone. A cone number 50/04 BC points was used, and then the excess portion of gutta-percha was cut off and compacted vertically. Group 2, was obturated using the cold lateral condensation technique with standardized gutta-percha and cement sealer AH-Plus. Once the lateral condensation was finalized, the excess portion of gutta-percha was cut and compacted vertically.

After 1 week, the roots were placed in the center of a cylindrical mold and vertically filled with a polyester resin (GamaGlass). All samples were stored at room temperature for 24 hours and 37 °C. Each root was sectioned horizontally at a thickness of approximately 0.2 mm in the cervical third, middle third and apical using a diamond disc cooled with water.

### Mechanical test

Three specimens were obtained for each prepared tooth, thus leaving 18 samples in each group. The specimens were analyzed in the Universal Testing Shimadzu Machine, with a metal needle device or punch, specially designed by our research group (11). This allows exerting force on the mass of the gutta-percha vertically. The punch was placed in a test tube with a borehole 1/8 inch, at one end fixing one end of the punch with epoxy clay (plastiloka ®). Once fixed, the sample was placed to the upper jaw and the lower jaw taking into consideration the measurement of the area of the gutta-percha. The machine was calibrated and the compression tests of all samples were performed.

To obtain the results of the force applied to the gutta-percha, the maximum effort to shift of the gutta-percha was recorded.

The data was collected on files according to the endodontic cement sealer. The adhesion strength was calculated by dividing the maximum tensile strength between the area of the duct for each specimen with the following formula:

$$\sigma = P/A(\text{effort} = \text{force/area}) \quad (1)$$

The units referred are MPa, thus, a conversion of units was used. The data was analyzed with a program that would allow us to find differences between the groups.

### Scanning Electron Microscopy (SEM)

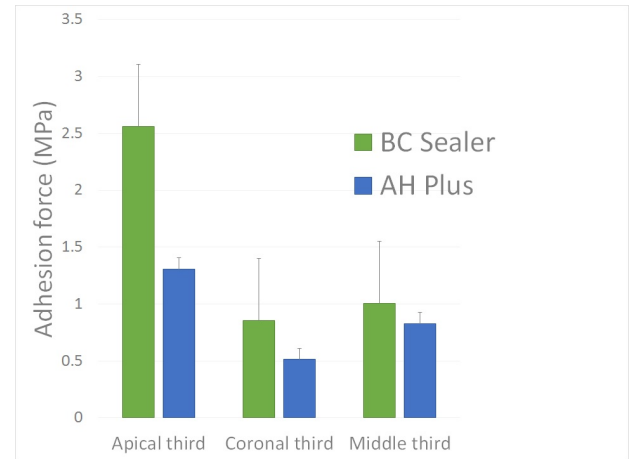
The scanning electron microscopy studies were performed in a microscope of field emission JEOL JSM 7600F, to observe if the sealants were adhered to the tooth after gutta-percha was punched out, samples were placed in a cylindrical container which as covered with a gold sheet through a plasma assisted cathodic pulverizator, to allow visualization since the samples are nonconductive.

## DISCUSSION AND RESULTS

An experimental, transversal and comparative study was conducted *in vitro* for comparing the adhesion strength of two sealing cements with different obturation techniques. There were no significant differences (using Kruskal-Wallis and median test), as these tests are used when the data does not follow a normal distribution.

### Mechanical test

The BC-Sealer took more force to move the gutta-percha ( $2.5619 \pm 0.6$  MPa) in the apical third compared to the AH-Plus ( $1.30486 \pm 0.73$  MPa). With the middle third, the BC-Sealer also occupied more force to move the gutta-percha ( $1.00416 \pm 0.51$  MPa) unlike the AH-Plus ( $0.82912 \pm 0.46$  MPa). Finally, in the coronal third, the BC-



**Figure 3.** Bond strength of the apical third, middle and coronal sealing of the two cements.

Sealer also needed higher power to move the gutta-percha ( $0.85804 \pm 0.17$  MPa) than the AH-Plus sealer ( $0.51252 \pm 0.2$  MPa) (Figure 3).

The tests of bond strength are not a complete replicate of the clinical performance of these and there is no correlation between the binding forces, but it has proven to be clinically successful, this provides valuable information comparing different sealer cements or obturation techniques. The blow out test is commonly used to evaluate the bond strength between the duct walls and the cement. Although this test is widely conducted, various studies have demonstrated a lack of uniformity in the experimental design and the results are often inconsistent [12].

In previous studies, tests that evaluated the accession of two sealants were performed: the MTA Fillapex and the AH-plus, all the roots were sealed with cement sealer only without using the gutta-percha. The results showed that the AH-Plus had greater adhesion than the MTA Fillapex and concluded that the MTA Fillapex achieved lower adhesion than the AH-Plus. In the present study the MTA Fillapex was not used, but other bioceramic (BC Sealer), which showed greater adherence than AH-Plus. Therefore, it can differ with Baechtold, et al. 2013, although the MTA Fillapex is



a first generation bioceramic, its chemical composition could also affect its binding capacity [9].

A recent study found that the reason of the non-adherence of the MTA Fillapex is the formation of apatite on its own surface (cement sealant) so the low binding was attributed to the dentinal tubules.

DeLong et al conducted a study that which evaluated the adhesion forces of the MTA Plus (Avalon Biomed Inc), the EndoSequence BC Sealer (Brasseler) and AH-Plus when used in a thermoplastic technique. BC-SC group had a statistically superior adhesion force than the MTA Plus-SC and the groups of AH Plus-CW, therefore the BC and the MTA Plus sealant has favorable binding resistance when used with a SC technique. This work concurs with results were the BC-Sealer with single cone technique was the one that obtained better results regarding its adherence [10].

A recent study, already reported a comparison between AH Plus and Endosequence BC sealers, but this work, focuses on the comparison of marginal adaptation of obturation with single cone technique, using the two sealers (AH Plus and Endosequence BC Sealer) and two different gutta-percha points (Protaper F4 e EndoSequence BC Points). The analysis showed the existence of areas with gaps and areas without gaps, in all of groups. In addition, when the percentage of gaps was analyzed, no significant differences were found in the apical, middle and coronal third. In this study, the combination of Endosequence BC Sealer and Endosequence BC Points yielded better results [13]. In our study, we just compared these to sealer evaluating just the adhesion forces and Endosequence BC Sealer also showed better results.

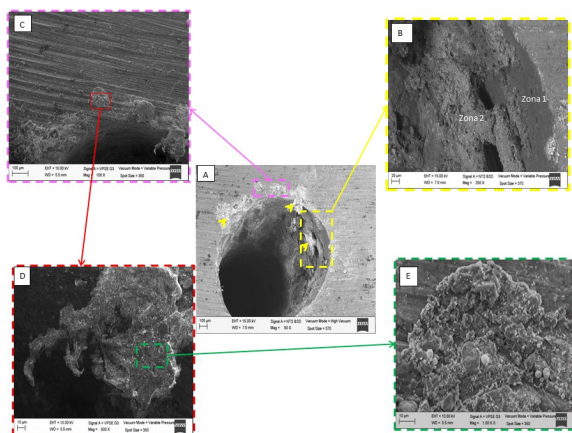
Finally, in another study, the adhesion strength of the BC-Sealer and the AH Plus was compared in the presence or absence of smear layer. In conclusion, the adhesion

strength of the BC-Sealer was equal to that of the AH-Plus with or without smear layer. In the present study the dentin debris of all groups was removed, however, it differs with this study, since the BC-sealer with single cone technique performed better than the AH-Plus to the dentin in the absence of smear layer [12, 14].

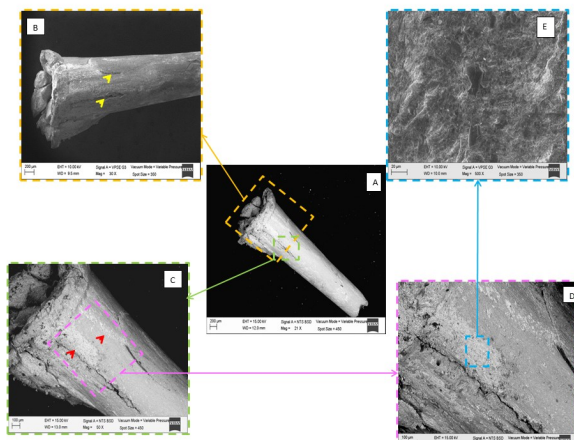
### Scanning Electron Microscopy (SEM)

Figure 4, shows how both sealants remain attached on the surface of the tooth, both sealer cements show same results in SEM images, so the discussion about both SEM images were equally explained. Image 4-A shows the general aspect of the transversal cut of the teeth, we observed residues of the sealants in the external and internal side of the sample (see yellow arrows). Image 4-B shows a closer view of the internal side of the teeth, where we observed the teeth without the cements (zone 1), and the other area of a white color corresponds to the cements (zone 2). This photograph shows certain zones where chemical interactions between the cement and the teeth exist can be seen, it shows a loss of dental material (rough zone). The image 4-C shows a closer view of the samples in the external side of the hole. Photograph 4-D indicates a closer view of the cement material with a similar morphology to the surface found in zone 2 in the interior of the teeth. Finally, in picture 4-E we observe a roughness which does not show any evidence of loss of dental material loss, this observation is evidence of a non-chemical interaction between cements and dental surface.

It is important to mention that the zones discussed are related to the interface of the gutta-percha and the cements and is not evidence of chemical interaction in this interface. According to these results, there is just a partial chemical interaction in the interface dental surface and cement, which confirm values of adhesion force reported previously.



**Figure 4.** Interaction between cements and dental surface.



**Figure 5.** Interaction between the sealers and the gutta-percha.

Figure 5 represents the general aspect of the gutta-percha, in image 5-A we cannot appreciate, hence there is not a chemical interaction between the interface cement-gutta-percha. Picture 5-B shows the superior zone of the gutta-percha where some cracks are observed (see yellow arrows). Image 5-C shows the superior zone of the gutta-percha is shown with small traces of the sealer (see red arrows). Nevertheless, 95% of the surface of the gutta-percha is free of the cement. Image 5-D shows the cement zone with an irregular surface and without any evidence of mechanical damage. Picture 5-E shows the morphology of the surface with the cemented area is shown; we do not appreciated any evidence of loss

of dental material or mechanical damage. These observations represent a non chemical interaction between the sealers and the gutta-percha.

## CONCLUSIONS

The differences between groups AH-Plus C.L. and the BC-Sealer were found on the adhesion force that was applied in the different thirds of the root canal. The sealer cement BC-Sealer proved to be the material with better adhesion in all thirds of the root canal being significantly more noticeable in the apical third. The two cements sealants are effective for the adhesion at the root canals, used correctly. Any of these, well used, will grant anyone an acceptable result.

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