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# Comparative study of adhesiveness of two endodontic root canal sealers

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# Comparative Study of adhesiveness of two endodontic root canal sealers

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## SUMARY

## ABSTRACT

Introduction: The endodontic treatment is a clinic procedure with the gold to preserve the dental pieces, aiming a mechanical and chemical debridement of the hole pulpar space and its correct obturation and sealing. In order to have a hermetic seal, endodontic cements are used together with an inert core material to achieve this same effect. Therefore, it is necessary to evaluate the different parameters that make these cements being an adjuvant factor to the success of the endodontic therapy. The following experimental project has the goal to access and compare the bonding adhesion (to the root canal walls as to the core material) of two endodontic cements: AH Plus ® and GuttaFlow Bioseal®.

Materials and methods: To conduct this study, there were collected 30 human teeth for the sample. The crowns of these teeth were sectioned, and they were mechanically adjusted to 14 mm of working length with ProTaper® Universal files. There was a division into two experimental groups for analyses: in experimental group 1 (GAH Plus®), the teeth were obturated with AH Plus®, using the single cone technique; and in experimental group 2 (GBioseal®), the teeth were filled with GuttaFlow Bioseal®, using also the single cone technique. The samples were divided into three sectioned areas (apical, cervical and middle), included in Tab 2000®, submitted to the push-out test, and then photographed with a microscope with a camera incorporated, and the scanned by ACT-1C program. The images were scanned after the push-out test and observed through the microscope.

Results: There are statistically significant differences between AH Plus® and GuttaFlow Bioseal® in the presence and material fracture observed.

Conclusion: AH Plus® represented a better sealing, with a percentage for failure of 64,4% of the cases (n=29) and the sealer *GuttaFlow Bioseal®* in 84,4% of the cases (n=38).

**Keywords:** endodontic sealers, adhesive failures, AH-Plus®, GuttaFlow Bioseal®

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# DEVELOPMENT

## 5.1 INTRODUCTION

The endodontic treatment is nowadays a very important therapy to be considered because of its effectiveness on maintaining the natural tooth. It prevents tooth extraction and local or systemic infections.

The endodontic treatment has been upgraded throughout times, because of constantly new technologies and material that are developed to obtain a maximum sealing of the root canal. (1)

The primary components for successful endodontic treatment are correct cleaning, shaping and sealing. (2) The main objective of this therapy is acquiring correct debriding, shaping and hermetic sealing of the root canal by establishing a fluid impervious seal, preventing re-infections and infiltrations by pathogens. (3) Clinical evidence demonstrates that the previous element reunited with a three-dimensional sealing can provide a success rate of nearly 100%. (2)

After preparation of the root canal, it should be performed a correct filling with an inert material, that prevents the progression of pathogens and bacteria and also the regeneration/reparation of the periapical tissue, confines the resistant bacteria in the root canal and prevents the penetration of periradicular exudates and oral fluids. (2,3)

In the course of time, many materials were introduced to maximize the filling of the root canal system, namely epoxic resins and bioceramic-based cements. They can be combined with core materials or used solo. (3,5)

There are some proprieties that the endodontic sealers need to fulfil in order for the successful outcome of the treatment. (6, 7, 8)

The filling of a root canal system is done by two materials: one being the core and other is the sealer. (9)

Since its introduction, gutta percha has been the standard core material for obturation (2) and it's also combined with endodontic sealer for bonding to the root canal. (2,5)

The bonding of the endodontic sealer to the intra-radicular dentin is advantageous to maintain the integrity of the interface that results, protecting the tooth from mechanical stresses, like the masticatory function. (3)

Nowadays the epoxy resin-based cements are used because of their reduced solubility, their apical seal and their micro-retention to the intra-radicular dentin. (10,11)

*AH Plus*® (Dentsply, Maillefer, Ballaigues, Switzerland) is an example of the group described in the previous paragraph. Is used in conjunction with gutta percha in vertical or lateral compaction.[2] It provides low solubility and disintegration, good radiopacity, high bond strength to the intra-radicular dentin and other desirable proprieties.[3,12] Although it is one of the most popular in use, this endodontic sealer does not bond with gutta percha as a core material, so it's sealing ability is still controversial[9].

Bio-ceramics are a biocompatible based ceramic material with heightened sealing ability, antibacterial and antifungal activity applied for use in medicine and dentistry. They have the ability to either function as human tissues or to resorb and encourage the regeneration of natural tissues. [13] They are biocompatible, nontoxic, do not experience polymerization contraction, they are chemically stable, have bioactive potential, and have low cytotoxic and genotoxic effects. [13]

A recently introduced alternative of bioceramic root canal filling material is *Gutta-flow Bioseal*® (Coltene/Whaledent, GmbH + Co. KG, Germany) that consists of a polydimethylsiloxane matrix highly filled with gutta-percha powder and nano-silver particles, which prevents the growth of bacteria[8]. It's referred that, when in contact with biologic tissue, the sealer releases natural factors for reparation and aids the regeneration of the surrounding tissues. In addition, it can create bonds with the master gutta percha cone, providing more fluid-tight seals. [7,8,12]

The push-out test is a tool that can be used to provide information about the bonding of the endodontic sealer material to the root canal walls. [3]

Camargo et al showed that there was no significant difference in the sealing capabilities of AH-Plus® and Gutta-flow® when used in combination with gutta-percha.[12] However, there can occur material fractures between the core material and the sealer, within the sealer/core material and the sealer and the intra-radicular dentin as a result of its adaptation.

An ideal endodontic sealer should adhere firmly both to dentin and to gutta-percha. [13]

Adhesiveness on the root-canal sealers to the dentinal walls seems advantageous for two main reasons: in a static situation, it should eliminate any space that allows percolation of fluids between the filling and the wall and in a dynamic situation, it is needed to resist displacement of the materials during subsequent manipulation.[14]

It's also necessary to consider the smear layer present after the root canal mechanical preparation [15], however its influence on the adhesiveness is still been investigated.

Thus, the aim of this study was to assess the adhesiveness and type of fracture of the *GuttaFlow Bioseal®* sealer in comparison to *AH Plus®* sealer.

## 5.2 MATHERIALS AND METHODS

For this study, the teeth used were obtained in the clinical practice of Coimbra's Hospital (CHUC) in the Dentistry Department, during the clinic of Oral Surgery. The identity of the patients remained unknown.

The criteria used to select the teeth were that they had to be monoradicular, with one root canal (Type I of Weine), without any lesion of caries, closed apex, and with no previous endodontic treatment. They also couldn't have any root fractures or reabsorptions.

### 5.2.1 Sample Preparation

There were reunited 30 teeth, then sterilized and kept in a solution of T-cloramine at 4ºC, until they were used. The crown was removed with *Carburundum* discs at high speed, perpendicular to the axis of the root, to obtain root segments with 14mm length.

The preparation of the root canal was performed with the *ProTaper® Universal* system, with the following file sequence: S2, F1, F2 and F3 (at a speed of 300rpm and torque of 2 N $cm^{-1}$) (*Dentsply Sirona*). The work length was established with a k15 file, until it was visible coming out of the apex, subsequently it was subtracted 1mm to the k15 file length and then registered the workng length for the specific tooth. The procedure after the use of each instrument was: irrigation of the root canal with a solution of NaOcl 3% (Canal Pro™, Coltène/Whaledent Inc. Langeneu/Germany), 2mL followed by apex permeabilization with a k10 file. It was used EDTA 17% (Canal Pro™, Coltène/Whaledent Inc. Langeneu/Germany), 1mL for 60 seconds to remove the smear layer, following final of saline solution (2mL), and then dried with paper points.

### 5.2.2 Endodontic sealers used for obturation

After root canal preparation, the samples were obturated with the two cements previously referred for comparison: *AH-Plus® and GuttaFlow Bioseal®*. The first one is a cement epoxic-based resins, which has 2 components: A (base): bisfenol A, Bisfenol F.; calcium thungstate, zirconia oxide, iron oxide and silica; and B (catalyzer): diamond based amina, N, N" -Dibenzil-5- oxanonane-diamine-1,9; TCD diamina; calcium thungstate, zirconia oxide, iron oxide, silica and silicone oxide. The second is a bioceramic sealer with a platin catalyzer, silicates, silicone oxide, silver microparticles, zinc oxide, zirconia dioxide and bioactive glass.

### 5.2.3 Sample sorting

The samples were randomly divided into 2 experimental groups:

1. Group 1: teeth filled with the technique of continuous wave and filled with a single cone (Guta-percha F3) and the endodontic cement based on epoxic resins, *AH-Plus®;*
2. Group 2: teeth filled with the technique of continuous wave, filled with a single cone (Guta-percha F3) and the endodontic cement based on bioceramic materials *GutaFlow Bioseal®*.

Each group comprised 15 teeth. After sealing, the roots were stored in 100% humidity at 37ºC for two weeks, to allow the complete setting time. The roots were fixated in Tab 2000 (*Kerr, Scafati, Italy)* and then sectioned into portions of 0,5-2,3 mm of thickness in the three sections cervical, middle and apical. The total number of the samples were 45 for each experimental group.

### 5.2.4 Push-out test description

The samples were submitted to bonding forces for measurement with the help of the push-out test, performed by a Universal machine (*Shimadzu AG - I, Shimadzu Corporation, Kyoto, Japan*).

The specimens were loaded into the Universal machine and then it was applied a compressive force in the surface of the sample material, from the coronal section of the root canal in direction to the apex. Then there were used three different points, with three different diameters, respectively 0,9mm, 0,7mm and 0,5mm. The load speed was 1mm/min until it occurred collapse and there was connection failure.

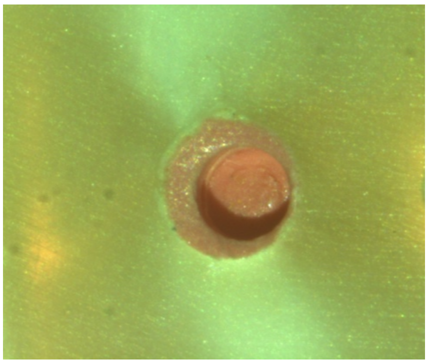


Figure 1 Group 1 sample (20x).

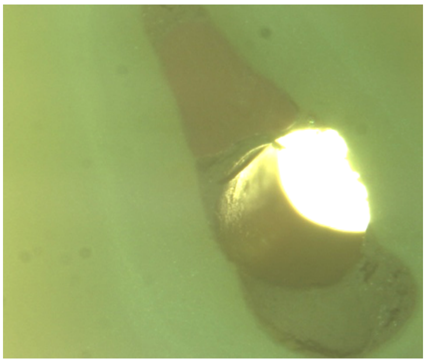


Figure 2 Group 2 sample (20x)

The maximum force applied to the material was measured in Newtons, (which finished when it reached zero), and the strength needed to occur a material dislocation was calculated in megapascals, MPa [16-21].

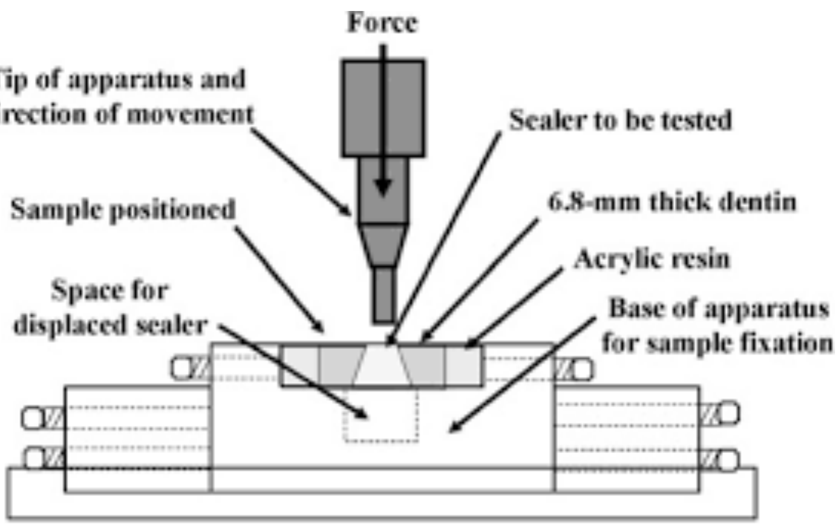



*Figure 3 Push out test illustration (Teixeira et all, 2009).*

## 5.2.5 Observation of the fractures and classification

The images for analysis were taken after the push out test, on a microscope with an ampliation of 20x, and images acquired through a copulated digital camera and treated with ACT-1C software. (*Nikon, High resolution, 12,6-megapixel DXM-1200C, Tokyo, Japan*; *Nikon, DXM-1200C, Tokyo, Japan*).

The fractures were classified into five categories:[20]

1. adhesive to the dentine: if the filling material dislodged from the dentine;
2. adhesive to the filling material: if the gutta-percha dislodged from the sealer;
3. mixed adhesive failure: if the gutta-percha dislodged from both the dentine and the sealer;
4. cohesive failure within the dentine: if the failure occurred in the dentine;
5. cohesive failure within the sealer: if the failure occurred in the sealer.

## 5.2.6 Statistical Analyses

The collected data was analyzed with the software SPSS (*Statistical Package for the Social Sciences)*, v.25, with a significance level defined at p<.005. The variables used include the type of cement (*AH-Plus*® and *GuttaFlow Bioseal*®), the type of fracture (1, 2, 3 4, and 5) and the sectioned sector of the teeth (apical, cervical, middle). Its statistical analyses included dispersion (standard deviation) and the Chi-square test to examine significative differences between the previous parameters.

## 5.3 RESULTS

The results obtained for this experimental study are described in Table I. On this analyses *AH-Plus®* sealer showed a percentage for failure of 64,4% of the cases (n=29) and the sealer *GuttaFlow Bioseal®* in 84,4% of the cases (n=38).

**TABLE I | Descriptive Analyses of the presence and type of fracture on each cement after the push out test.**

| Fracture | *AH-Plus®* (n=45) | | | | Chi-square | *GuttaFlow Bioseal®* (n=45) | | | | Chi-square |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | C | M | Total | | A | C | M | Total | |
| **Absent** | 33.3 (5) | 33.3 (5) | 40.0 (6) | 35.6 (16) | $\chi^2$=0.2 p=.908 | 6.7 (1) | 13.3 (2) | 33.3 (5) | 15.6 (7) | $\chi^2$=2.4 p=.306 |
| **Present** | 66.7 (10) | 66.7 (10) | 60.0 (9) | 64.4 (29) | | 93.3 (14) | 86.7 (13) | 66.7 (10) | 84.4 (38) | |
| **Type** | | | | | | | | | | |
| **Type 1** | .0 (0) | .0 (0) | .0 (0) | .0 (0) | **$\chi^2$=10.4 p=.034** | .0 (0) | .0 (0) | .0 (0) | .0 (0) | $\chi^2$=2.6 p=.268 |
| **Type 2** | 20.0 (2) | 43.0 (7) | 11.1 (1) | 34.3 (10) | | 42.9 (6) | 30.8 (4) | 63.6 (7) | 44.7 (17) | |
| **Type 3** | 80.0 (8) | 30.0 (3) | 88.9 (9) | 65.5 (19) | | 57.1 (8) | 69.2(9) | 36.4 (4) | 55.3 (21) | |

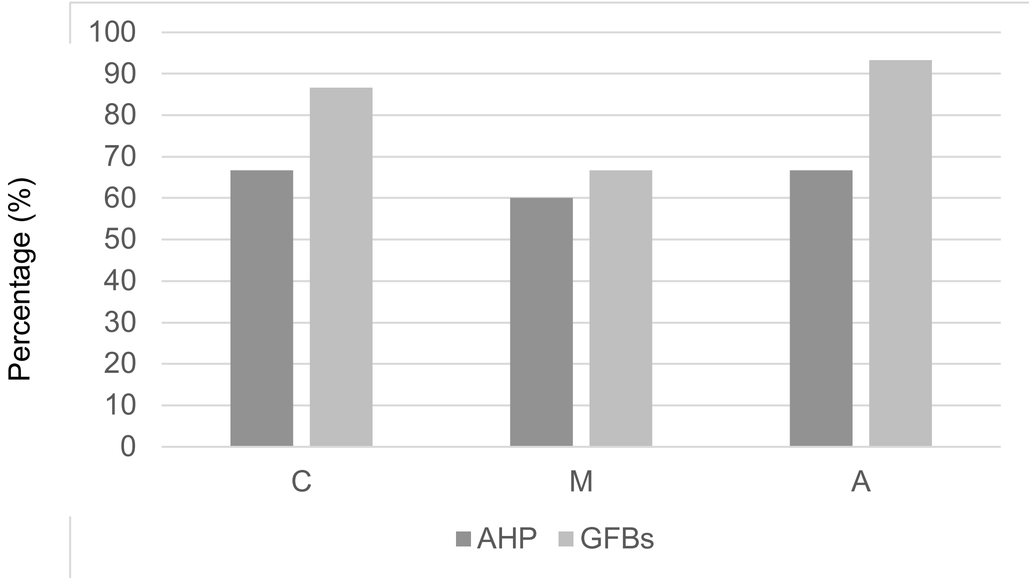
**Legend: A – apical zone; C – Cervical zone; M -middle zone**

Regardless of the type of sectioned area, there was a significant association between the sealer *GuttaFlow Bioseal®* and a higher occurrence of registered fractures ($\chi^2$=4.7; p=.030), 84,4%. These sealers showed to be also associated to a higher frequency of mixed adhesive fractures (type 3), although the *AH-Plus®* sealer presented a lower number than the sealer *GuttaFlow Bioseal®*.

However, considering each sealer individually, the *AH-Plus®* sealer showed a significant correlation between the type of failure and the sectioned area, where the apical and middle areas tend to present a higher frequency of type 3 mixed fractures.

The comparison between the percentage of fractures of *AH-Plus®* and *GuttaFlow Bioseal®* and respective sectioned areas are illustrated on figure 4.

**Figure 4 Percentage values for presence and location of fractures in both sealers**




**Legend: AHP – *AH-Plus®; GFBs - GuttaFlow Bioseal®*; A – apical zone; C – Cervical zone; M -middle zone**

## 5.4 DISCUSSION

The aim of this study was the assessment the adhesiveness and the type of material fracture on human teeth sealed with *GuttaFlow Bioseal®* and *AH Plus®*.

The longevity and success of endodontic treated teeth depends on numerous factors: related to the tooth itself (quantity of remaining enamel, for example), to the root canal treatment procedures (the ability to promote decontamination) and the intracanal cementation technique. [(24)]

Endodontic sealers, which ideal characteristics were mentioned before, have traditionally been used to seal dentinal tubules, creating a homogenous interface between the obturation material and the dentinal walls and preventing the re-infection of the root canal and the periapical tissues. [(21,23)]

The adhesives of the materials to the root canal is a must have in the sealer's proprieties, because it can prevent radicular fractures, low risk of micro infiltration by bacterial material and fluids, and longevity to the teeth that are treated with and endodontic procedure. [(3)]

The use of epoxic-based resin sealers is because of its physical and chemical proprieties, namely the apical sealing, correct biological function, micro-retention to the dentine tissue and biocompatibility. [(11,9)] AH Plus® is an example of this type of sealers and it's frequently used because of its low solubility and lasting structural stability. [(24,25)]

The bioceramic sealers, like GuttaFlow Bioseal® have been referred in the endodontic area because they present great biocompatibility because of its composition similar to the hydroxyapatite and are capable to promote a hilling response of the surrounded tissues. [(6)] They are also osteoconducters and osteoinducters, because they lead to bone formation. [(6,9)] Since they contain calcium silicate, they are considered promising as a result of improving the bonding ability as well as chemical structure similar to the hydroxyapatite that resides in the bone and teeth. [(9,11,26)]

Various studies demonstrate that the sealers based on epoxic resins have a higher bonding strength to the root canal, and therefore, the interface between the material and the teeth is expected to be better as well. This can be explained by the existent covalent connection between the epoxic ring and the amine groups that are exposed laterally in the collagen net, and also because of its low contact polymerization reaction and lasting stability. [(5,9,13)]

In this study, the AH-Plus® sealer presented lower value of facture presence (64,4%) than the GuttaFlow Bioseal® (84,4%), regardless of the tooth region observed.

Regarding the three sectioned areas, the GuttaFlow Bioseal® presented higher values for fractures type 3 for the apical and cervical zones. The apical fractures can be explained because of the of obturation technique ("single cone filling"), since the guta-percha can't fill completely the apex area there could be more concentration of sealer.[27] On the other hand, the cervical fractures can be explained by the one of the limitations of the push-out test, once it can occur completely dislodgment of the guta-percha if the point used to perform the test is too small. [28, 29]

The GuttaFlow Bioseal® values for fracture can be related to low bonding strength of gutta-percha, because several studies refer that it doesn't bond to the dentine and this sealer contains gutta-percha particles in its composition. [7,10,29]

The use of the push-out test in this study was to evaluate the bonding of the materials in different areas, even if the bonding strength have low values. [28] We tried to search optimal conditions to perform this test, but it has some limitations such as: the sample thickness, diameter of the test point and root canal diameter. [19] Since there are some limitations, the evaluation of an endodontics sealer should not be evaluated only by the push-out teste results. [23]

It's necessary that the test point adapts to the root canal, but the difficulty of this process is obvious, we used three points to allow the best adjustment. They couldn't be too small, because if that happened it would only penetrate the core material, not evaluation its adhesiveness.

The adhesiveness values reported on GuttaFlow Bioseal® sealer, may lead manufacturers to improve this parameter by increasing bonding either to dentin and/or to gutta-percha, to lower the presence of fractures and allow a higher penetration on the dentin tubules and, therefore, it's is expected a minimal micro infiltration as possible.

## 5.6 CONCLUSION

In this study *AH-Plus®* sealer presented statistical differences between the values of fracture and better adhesiveness than the *GuttaFlow Bioseal®*.

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