

Original Research Article

Adhesion and formation of *tags* from MTA Fillapex compared with AH Plus® cement

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Abstract

Introduction and Objective: The aim of this study was two-fold: 1) to evaluate, in vitro, the shear bond strength of two sealers by push-out test and 2) to assess the failures after displacement. Additionally, the formation of tags was observed by SEM. **Material and methods:** Forty mandibular premolars were selected and the canals were subjected to biomechanical preparation with rotary instruments. These specimens were divided into two groups according to the sealer (n = 20): GI – MTA Fillapex and GII – AH Plus. All roots were filled with sealer only, without gutta-percha. After a period corresponding to three times the setting time of the sealer, the roots were sectioned transversely into slices of 1 mm thickness, to obtain one slice from the cervical third, to be used in the push-out test. Following, two slices of each group were randomly chosen for ultra-structural analysis by scanning electron microscopy (SEM). The data obtained in shear bond strength test were subjected to statistical analysis. **Results:** AH Plus cement exhibited higher shear bond strength values (1.332 ± 0.75 MPa) than MTA Fillapex (0.071 ± 0.07 MPa), with statistically significant differences. **Conclusion:** MTA Fillapex has a low bond strength with less formation of tags than AH Plus.

Introduction

One of the desirable physical-chemical properties of the endodontic cements is adhesivity to the root canal walls [6]. Thus, when meeting this feature, a hermetic filling can be obtained through the sealing of root canal, promoting the apical repair, and avoiding the percolation of fluids to the periapical tissues and consequently preventing endodontic reinfections [3, 12].

Currently, the association of the endodontic cement with gutta-percha points is the gold standard in endodontic obturation, mainly because of lack of adhesion of the gutta-percha to the dentinal walls. The flowing property of the endodontic cement should be also taken into consideration, in order to fill the spaces between the gutta-percha and the canal wall, therefore providing a sealing with better quality [4], and enabling the filling of lateral canals and isthmuses [15].

The cements most commonly used today are based on epoxy resin, calcium hydroxide, zinc oxide and eugenol, and glass ionomer. Recently, MTA cement has been also employed and studies have aimed to evaluate the sealing capacity of resin-based cements and the biological repairing of mineral trioxide aggregate which is the new filling material. The following clinical characteristics of MTA-based cement have been reported: higher radiopacity; easy removal in cases of retreatment; excellent flowing providing the easy filling of depressions and lateral canals; low solubility; releasing of calcium ions, which induces the bone regeneration; high alkalinity, which results in an antibacterial material inducing neoformation of peri-radicular cementum.

Because of its composition, MTA-based cements exhibit an excellent biocompatibility to human tissues, making it an attractive material to both the professionals and researchers. Notwithstanding, little has been known on its adhesivity, which is fundamental for endodontic treatment success.

Most of the endodontic cements have demonstrated inadequate biological activity and adhesive capacity [2, 7]. Consequently, many studies have been constantly conducted to assess their physical, chemical and biological properties, which vary according to the composition of each material.

Therefore, the aim of this study was to evaluate the capacity of adhesion to dentinal walls and the formation of tags of MTA Fillapex compared with AH Plus cement.

Material and methods

This study was submitted and approved by the Ethical Committee in research of the Positivo University under protocol number 088/11.

Forty mandibular human premolars were selected with minimum root length of 11 mm, determined through digital caliper (Starret 799, Athol, USA) and radiographed at buccal-lingual direction. Inclusion criteria comprised: lack of endodontic treatment, bone resorptions and calcifications; and complete formation of root apex. After selection, the teeth were extracted, cleaned with the aid of a periodontal curette and kept into 0.1% thymol solution at temperature of 9°C. Before the study, the teeth were washed into running water for 24 hours, aiming to eliminate the thymol remnants.

Following, the teeth were cut with the aid of carborundum discs mounted into a straight handpiece at low speed (Kavo do Brasil, Chapecó, Brazil) close to the enamel-cementum junction so that all roots measured 11 mm in length. Then, the specimens were kept into 0.9% saline solution in an incubator at temperature of 9°C to avoid dehydration.

The working length of all samples was determined at 10 mm. Crown-down technique was used with apical stop of 0.60 mm for all specimens. During all preparation, 2.5% sodium hypochlorite (Asfer Indústria Química Ltda., São Caetano do Sul, Brazil) was used as irrigant solution. Final irrigation was executed with 10 ml of 17% ethylenediaminetetraacetic acid (EDTA) (Farmácia-Escola Universidade Positivo, Curitiba, Brazil), followed by irrigation with 10 ml of distilled water and drying with absorbent paper points (Dentsply-Maillefer, Petrópolis, Brazil).

The specimens were randomly divided into two groups (n = 20) according with the endodontic cement used: GI - AH Plus (DeTrey Dentsply, Konstanz, Germany), GII - MTA Fillapex (Angelus, Londrina, Brazil). The canals were filled only with endodontic cement, without using gutta-percha points so that gutta-percha/cement interface did not interfere in the shear bond strength test.

The roots were cut at 1 mm slices, with the aid of diamond discs mounted into cutting machine (Isomet 1000 - Buehler, Lake Bluff, USA). A cervical third slice of each specimen was selected to be tested in the universal testing machine (Emic

DL2000 – EMIC, São José dos Pinhais, Brazil), at crosshead speed of 0.5 mm/min. A stainless steel device was used to place the samples so that the surface of smaller diameter of the root canal was turned up, aligned with the rod employed to push the cement until the sample displacement. The rods had tips with 1 mm in diameter.

The force (F) required to displace the filling material, in kilonewtons (kN), was transformed into Newton (N), and expressed in megapascal (MPa) by dividing the force value (N) by the adhesion area of the filling material (SL), in mm². Thus, the formula employed to relate these measures was: $\sigma = F / SL$.

The calculation of the area (SL) was obtained according to the following formula:

$$SL = \pi(R + r)\sqrt{h^2 + (R - r)^2}$$

SL = lateral area of the cone trunk; $\pi = 3.14$; R = mean radius of the coronal canal, in mm; r = mean radius of the apical canal, in mm; h = height related to the side of the cone trunk, in mm.

After push-out test, the cuts were assessed with the aid of a stereoscopic lens (ZEISS; Stemi 2000-C, Germany), at x40 magnification, to verify the failure type, which was classified as: 1) adhesive – when the root canals were free of filling material; 2) cohesive – when the filling material completely covered the canal walls; 3) mixed – when there were areas covered by and free from filling material.

Data were submitted to statistical analysis to verify the sample normality and determine the proper statistical test.

Next, two specimens of each group were randomly selected for ultra-structural analysis in scanning electronic microscopy (SEM): one sectioned at the longitudinal direction and other at the cross-sectional direction in order to analyze the tags of cements within the tubules.

The specimens for SEM analysis were kept into 2.5% glutaraldehyde solution, buffered with 0.1 mol/l sodium cacodylate (pH = 7.4) for 12 hours in an incubator at 4°C. Following, the specimens were submitted to three baths in 0.1 mol/l sodium cacodylate (pH = 7.4) (for 20 min each) and dehydrated in increasing ethanol (Farmácia-Escola Universidade Positivo, Brazil): 25%, 50%, 75%, 95% (for 20 min of immersion into each solution) and 100% for 1 hour.

The specimens were dried in an incubator at 37°C for 24 hours, placed into a vacuum chamber and covered by gold of about 300 Å (Bal-Tec SCD 030; Leica Microsystems, Germany). The analysis was performed in scanning electronic microscopy (Jeol JSM-6360LV, JEOL, Milestones, USA).

In the qualitative analysis of the photomicrographies, the formation of cement tags and their aspect were analyzed.

Results

Push-out test

The values obtained by push-out test, in kN were transformed into MPa and submitted to statistical analysis with SPSS software (IBM, Armonk, USA).

Table I - Mean, standard deviation, minimum and maximum values, confidence interval for push-out test

| | N | Mean | Standard deviation | Standard error | 95% Confidence interval | | Minimum | Maximum |
|--------------|-----------|---------------|--------------------|----------------|-------------------------|---------------|-------------|-------------|
| | | | | | Lower bound | Upper bound | | |
| MTA Fillapex | 10 | 0.0719 | 0.0708 | 0.0224 | 0.0212 | 0.1226 | 0.01 | 0.19 |
| AH Plus | 10 | 1.3321 | 0.7557 | 0.2389 | 0.7915 | 1.8728 | 0.69 | 2.66 |
| Total | 20 | 0.7020 | 0.8311 | 0.1858 | 0.3130 | 1.0910 | 0.01 | 2.66 |

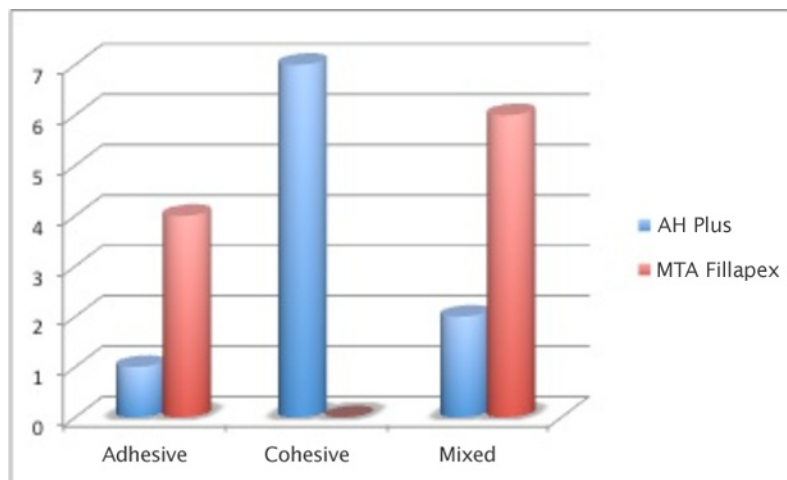
Based on the normality of the samples, one-way ANOVA was chosen (table II).

Table II - One-way ANOVA

| | Sum of squares | Degree of freedom | Mean of squares | F | p |
|---------------|----------------|-------------------|-----------------|--------|---|
| Groups | 7.941 | 1 | 7.941 | 27.566 | 0 |
| Within groups | 5.185 | 18 | 0.288 | | |
| Total | 13.125 | 19 | | | |

According to one-way ANOVA, there were statistically significant differences ($p < 0.05$) between AH Plus and MTA Fillapex cements. AH Plus cement exhibited the highest bond strength values (1.332 ± 0.75 MPa) than those of MTA Fillapex cement (0.071 ± 0.07 MPa).

The analysis of the failures observed in stereomicroscopy is seen in graph 1.



Graph 1 - Failure types after shear bond strength test. Data per group

There was the predominance of the cohesive failure for AH Plus and mixed failure for MTA Fillapex. Adhesive failure occurred in both groups, with greater prevalence for MTA Fillapex.

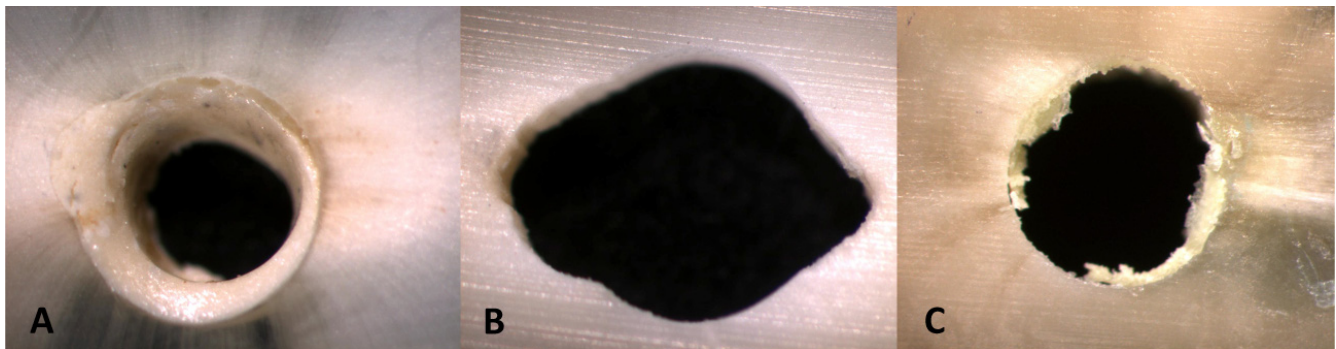


Figure 1 - Images obtained by stereoscopic lens, at x40 magnification for failure type analysis. A) cohesive failure, when the filling material completely covered by the canal walls; B) adhesive failure, when the root canal walls were completely free from the filling material; C) mixed failure, when there were areas covered by and free from filling material

Scanning electronic microscopy (SEM)

SEM analysis showed a greater formation of tags in the teeth filled with AH Plus, while the teeth filled with MTA Fillapex exhibited little or none formation of tags (figure 2).

At higher magnification, it was possible to observe the aspects of each cement: AH Plus was smoother and compact and MTA Fillapex was rougher and sparse.

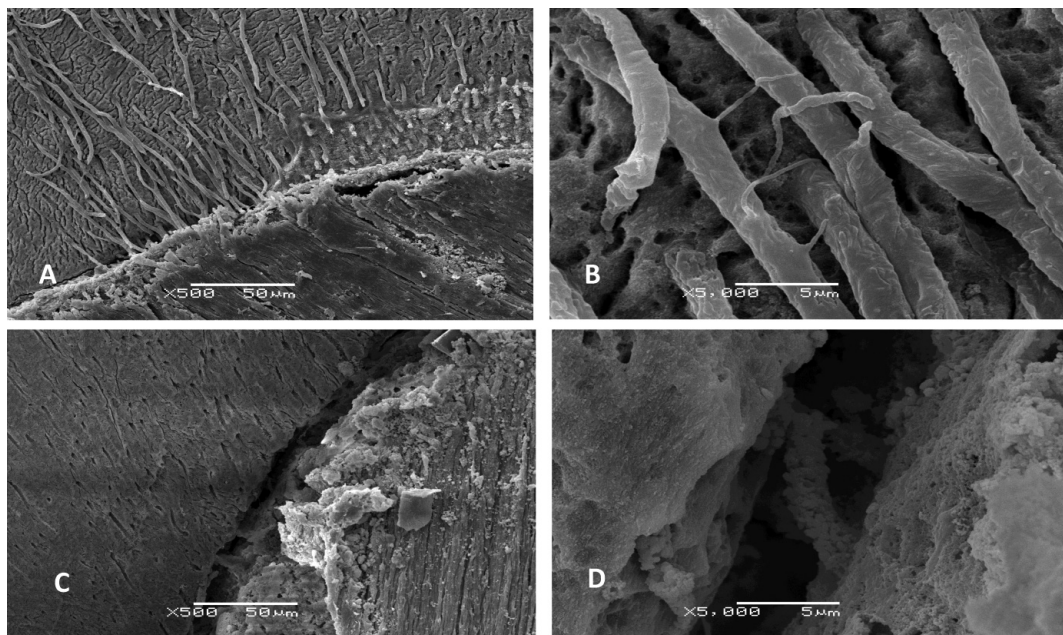


Figure 2 - Photomicrographies at x500 and x5000 magnification. A) Cross-sectional cut of AH Plus specimen: *tags* within tubules; B) Longitudinal cut of AH Plus specimen: smooth and compact aspect of the *tags*; C) Cross-sectional cut of MTA Fillapex specimen: lack of *tags* within the tubules and cement detached from the dentinal wall; D) Longitudinal cut of MTA Fillapex cement: rough and sparse aspect of the cement

Discussion

The association of the endodontic cement with gutta-percha points is the gold standard in the filling of root canals. The bonding capacity of the filling material to the dentinal wall is desirable for maintaining the integrity of the cement/dentine interface during displacement forces, as those occurring in the preparation of intraradicular posts, aiming to prevent marginal leakage [8].

In this present study, AH Plus cement exhibited better statistically significant results than those of MTA-based cement. The best adhesion force of epoxy resin-based cements have been studied through the comparison with other endodontic cements [10, 11, 14].

Prior studies have explained that the highest bond strength values obtained by the epoxy resin-based cements are because the capacity of creating a covalent bonding with an opened epoxy ring to any amine group exposed in collagen, giving long-

term dimensional stability and low polymerization tension [5, 9, 14].

The chemical composition of MTA-based cement could also influence on its bonding capacity [13]. A recent study discovered that the rationale behind the low bonding strength of MTA Fillapex is its low bonding capacity to dentinal tubules because of the formation of apatite by MTA, over its own surface, thus creating a similar structure that is different from that of the *tag* which prevents its leakage [11].

When exposed to scanning electronic microscopy, AH Plus exhibited longer and uniform *tags*, showing its higher mechanical imbrication and resulting in greater bonding capacity [10], while MTA Fillapex cement displayed little or none formation of tags, confirming the studies of Sagsen *et al.* [11].

Based on the results of this present studies, it could be observed that the material composition directly influences on its physical-chemical behavior.

Conclusion

This present study concluded that MTA Fillapex cement has low bond strength and little formation of tags compared with AH Plus cement.

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