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Influence of MTA powder handled with distilled water or phosphate buffered saline in push-out performance

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• **Conflicts of interest: none declared.**

Abstract

Objective: to investigated the bond strength of MTA powder handled with distilled water (DW) or phosphate buffered saline (PBS). **Material and Methods:** two horizontal cross-section were prepared in the root of fifteen incisors, followed by drilling of two canal-like holes on its axial surface. Holes were filled with MTA with DW or PBS. Load was applied until MTA displacement. Mann-Whitney and Friedman tests were selected to establish the influence of independent variables on push-out strength. **Results:** MTA handled with DW and PBS showed similar values ($p>0.05$). **Conclusion:** DW or PBS do not interfere in push-out bond strength of MTA.

Keywords: Dental materials; MTA handling; PBS; Push-out; Root canal obturation; Root canal therapy.

Introduction

Since the introduction of mineral trioxide aggregate (MTA), it has been widely used for root-end filling, perforation repair, pulpotomy, pulp capping, and formation of an apical barrier in necrotic open apices of the teeth because of the good biocompatibility, sealing ability, and its ability to promote hard-tissue formation.[1] MTA is composed of tricalcium silicate, dicalcium silicate, tricalcium aluminate and tetracalcium aluminoferrite, bismuth oxide, and other mineral oxides.[1] MTA is a water-based cement usually provided in pre-dosed powder and distilled water (DW) that are jointly mixed (in a powder/water ratio of about 0.33) to obtain a homogeneous paste. The powder consists of fine hydrophilic particles, which form a colloidal gel in the presence of water or moisture that solidifies to hard cement.[2]

When immersed in diverse storage media such as DW and phosphate-containing solutions [e.g., phosphate buffered saline solution (PBS)], precipitates of feasible bioactivity are formed on MTA's surface.[3] The precipitation occurrence was granted to a presumable interaction of the released calcium ($Ca2+$) with the surrounding fluid environment.[3] Previous investigations showed the formation of apatite-like crystalline structures resulting from the interaction between MTA and PBS,[4,5] which might positively influence the sealing ability of these biomaterials.[5] In such studies MTA was inserted in contact with such synthetic tissue fluids. The present study investigated the push-out bond strength of MTA powder handled with distilled water (DW) or phosphate buffered saline (PBS) solution. We hypothesized that MTA powder handled with PBS will take advantage regarding the push-out performance when compared to MTA handled with DW.

Material and Methods

• Estimation of Sample Size

According to a previous study with similar methodology, an effect size (0.74) was added to a power $\beta = 95\%$ and a $\alpha = 5\%$ inputs into an F test family between two independent means (G*power 3.1 for Macintosh).[6] As a result, a minimum size of 16 disc samples was then requested.

• Selection and Initial Preparation of Specimens

The Local Ethics Committee approved this research. Fifteen human permanent upper incisors were selected and cleaned with periodontal curettes and 5.25% sodium hypochlorite (NaOCl). Coronal and apical segments were removed from all teeth, resulting solely in a segment from the middle third. From this portion, which presented 10 mm in length, two horizontal cross-section (1±0.1 mm thick) were prepared by the use of a low-speed saw (ISOMET, Buehler Ltd., Lake Buff, IL, USA) and a diamond disc (Buehler Ltd. Lake Bluff, IL, USA). All this process was performed under uninterrupted watering. The final thickness of specimens was proven with a digital caliper that presented an accuracy of 0.001 mm (Avenger Products, North Plains, OR, USA).

• Production of Canal-Like Holes in Root Slices

After preparation of the total of thirty root slices, a 0.8 mm cylindrical carbide bur (Kommet, Santo André, São Paulo, Brazil) was selected to drill two canal-like holes in such a way as to be parallel to the main root canal. Under permanent watering, holes were perpendicularly drilled to the surface of all slices using a vertical drill stand (Dremel Workstation 220, Mount Prospect, IL, USA). A minimum 1 mm space between holes, outer walls of slices and main root canal was respected.

After canal-like holes production, root slices were submitted to the following standardized irrigation protocol:[7]

1. 2.5% NaOCl - 15 min;
2. Bidistilled water - 1 min;
3. 17% EDTA - 3 min;
4. Bidistilled water - 1 min;
5. 2.5% NaOCl - 1 min;

6. Bidistilled water - 1 min.[7]

Canal-like holes were dried by the use of paper points. Then, the two holes of the same root slice were filled with gentle vibration by White MTA (Angelus, Londrina, PR, Brazil) handled with DW or PBS. For that, one sachet of MTA were mixed during 30 seconds with 1 drop of DW or PBS until obtaining an homogeneous mixture with a consistency similar to wet sand, according to the manufacturers' instructions. Afterwards, the two slices extracted from the same root were randomly distributed in order to be stored in one of the time periods: 7 days or 30 days (http://www.random.org).

• Push-Out Bond Strength Test

After storage of specimens during both time points, in which slices were maintained at 37°C, with gauzes moistened in DW, push-out test was initiated. For that, a device that presented a 0.6 mm plunger tip of was placed above the tested MTA. Load was stably applied in a coronal–apical direction, by an universal testing machine (Instron, Canton, MA, USA) at a crosshead speed of 0.5 mm/min. During loading, a graphic of load (N) × dislodgement (mm) was produced, until MTA union with dentine fail. The push-out bond strength was estimated to reach values in MPa, according to the following formula:[6,7] Push-out median value (MPa) = Maximum load (N) / Adhesion area of root canal sealers (mm²).

• Statistical Analysis

As data did not adhere to a Gaussian Curve (Shapiro-Wilk test, $p<0.05$), rank-based procedures were selected. Mann–Whitney and Friedman tests were respectively selected to establish the influence of the independent variables (MTAs tested and time-periods) on the push-out values (dependent variable).

Results

MTA handled with PBS showed similar bond strength values to MTA handled with DW, in both time-points ($p>0.05$). However, the periods of storage (7 and 30 days) significantly influenced the individual results of each MTA group ($p<0.05$) (Table 1).

Table 1. Mean and standard deviation (±SD) of the push-out bond strength of MTA handled with PBS or DW in the different tested time points (7 days or 30 days)

	MTA and DW	MTA and PBS
7 days	1.0±1.3^{A}	1.2±1.4^{A}
30 days	1.6±2.1^{B}	1.8±2.2^{B}

* DW = distilled water, MTA = mineral trioxide aggregate, PBS = phosphate buffered saline solution. Different letters indicate significant differences at P=0.05

Discussion

The preparation of MTA powder in association with PBS did not showed advantages in results regarding push-out values of MTA handled with distilled water group in both periods evaluated in the present study. Therefore, our hypothesis was rejected. Previous studies have demonstrated that the immersion or exposure of MTA in PBS can significantly increase the bond strength to dentine as a result of the formation of an apatite layer when in contact;[4,5] however, to the best of the authors knowledge, this is the first time that push-out of MTA handled with PBS is evaluated. The small amount of PBS used during MTA′s handling may be insufficient to generate any difference in the push-out outcomes when compared to MTA handled with distilled water.

Physical properties and hydration behavior of MTA are influenced by the effects of the storage medium - environmental pH and presence of ions - on MTA composition.[2] Therefore, in order to eliminate possible interferences that the storage medium may cause in the analysis of this material, specimens were preserved with gauzes moistened in distilled water before the push-out assay. Several studies employed distilled water as storage medium during experiments of MTA's properties.[1,2,5]

For both materials, push-out bond strength was higher at 30 days ($p<0.05$). This is consistent with previous reports, which demonstrated that bond strength values are prone to rise with time.[5,8] This may be justified by the hydration and expansion processes of MTA.[1,9,10]

To increase the internal validity of the push-out model, two artificial standard holes were created in dentine slices, providing the same dentine source to both materials.[6] Therefore, confounding factors associated with dentine heterogeneity present in different teeth and in different regions of the same root were eliminated.[7] In addition to that, an equal cylindrical size for all canal-like holes eliminated relevant biological bias, since it standardized the internal root canal anatomy of the MTA's groups. Artificial canal-like holes undertaken allowed the creation of even cleaning and shaping circumstances, which is virtually impossible to reach when considering randomized small-sized test groups of root filled teeth.

Conclusion

In conclusion, MTA powder handled with distilled water or PBS solution presented similar performance and, therefore, the use of both of these vehicles do not interfere in push-out bond strength results. Future studies should evaluate the influence of handling MTA with PBS in other outcomes, such as biomineralization.

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Mini Curriculum and Author's Contribution

1. Paula Mauro Botelho – DDS. Contribution: bibliographical research, experimental procedures, manuscript writing.
2. Marina Carvalho do Prado – DDS and MSc. Contribution: bibliographical research, experimental procedures, manuscript writing.
3. Nancy Kudsi Carvalho – DDS and MSc. Contribution: manuscript writing, manuscript review, image editing.
4. Edson Jorge Lima Moreira – DDS and PhD. Contribution: manuscript writing, manuscript review.
5. Emmanuel João Nogueira Leal Silva – DDS and PhD. Contribution: manuscript review, statistical analysis, work supervisor and paper submission.

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