Revista Odontológica Mexicana
Facultad de Odontología

Vol. 22, No. 1 ● January-March 2018
pp 34-38

ORIGINAL RESEARCH

Microleakage in MTA-type dental cement modified with wollastonite and bioactive glass

Microfiltración en un cemento dental tipo MTA modificado con wollastonita y vidrio bioactivo

María Carolina Mendoza Herrera,* Abigailt Flores-Ledesma,§ Federico Humberto Barceló Santana§

ABSTRACT

Retro-filling material such as MTA (mineral trioxide aggregate) should be biocompatible, easy to handle, with low or nil solubility as well as dimensionally stable in order to avoid filtrations associated to volumetric changes. **Objective:** To measure filtration in a MTA-type dental cement modified with wollastonite and bioactive glass. **Material and methods:** Eight groups were established: MTA Angelus (control), MTA Exp (white Portland cement plus 20% wt of bismuth trioxide), another six groups were formed with the addition to MTA Exp of 10, 20 and 30% wt of wollastonite and bioactive glass. Single rooted teeth, with straight root and closed apex were prepared with crown-down technique with balanced forces in order to obtain standardized diameter to fit a number 40 master apical file; 3 mm from the apex were excised, 3 mm deep retro-cavities were prepared with ultrasound point, where cements were placed, apical end was submerged in a 2% methylene blue solution for 24 hours. **Results:** MTA Exp exhibited least filtration with an average of 0.66 mm, WO10 group exhibited the greatest leakage with average of 1.61 mm. MTA Angelus, used as control exhibited 0.71 mm microleakage. Statistically significant differences were found with WO10 (ANOVA $p < 0.001$), Dunett $p < 0.001$). **Conclusions:** It was observed that in the case of cements with aggregate of wollastonite and bioactive glass, microleakage decreased according to the aggregate's percentage. For microleakage measurement, use of other supporting techniques is advised.

RESUMEN

Un material de retroobturación como el MTA (*Mineral Trioxide Aggregate*) debe de ser de fácil manejo, biocompatible, tener baja o nula solubilidad y ser dimensionalmente estable para evitar filtraciones asociadas a los cambios volumétricos. **Objetivo:** Medir la filtración en un cemento dental tipo MTA modificado con wollastonita y vidrio bioactivo. **Material y métodos:** Se establecieron ocho grupos: MTA Angelus (control), MTA Exp (cemento Portland blanco más 20 wt% de trióxido de bismuto), otros seis grupos se formaron con la adición de 10, 20 y 30 wt% de wollastonita y vidrio bioactivo al MTA Exp. Dientes permanentes uniradiculares, raíz recta y con ápice cerrado fueron preparados con técnica crown-down con fuerzas balanceadas para obtener un diámetro estandarizado a lima apical maestra #40. Se cortaron 3 mm del ápice se prepararon retrocavidades de 3 mm de profundidad con punta de ultrasonido donde fueron colocados los cementos, el extremo apical fue sumergido en solución de azul de metileno al 2% durante 24 horas. **Resutlados:** MTA Exp fue el que presentó menor filtración con un promedio de 0.66 mm, mientras que el grupo de WO10 fue el de mayor con 1.61 mm. MTA Angelus usado como control presentó 0.71 mm de microfiltración, se encontraron diferencias estadísticamente significativas con WO10, (ANOVA $p < 0.001$, Dunett $p < 0.001$). **Conclusiones:** Se observa que en el caso de los cementos con los agregados de wollastonita y vidrio bioactivo la microfiltración disminuye conforme aumenta el porcentaje del agregado, se sugiere el uso de otras técnicas complementarias para medir la microfiltración.

Key words: MTA, wollastonite, bioactive glass, microleakage.
Palabras clave: MTA, wollastonita, vidrio bioactivo, microfiltración.

INTRODUCTION

During dental treatment, communication paths between root canal and periodontium occur sometimes, these must be filled in order to prevent filtration of fluids and bacteriae. Mineral Trioxide Aggregate (MTA) was first developed by Torabinejad et al in 1993[1,2] as an hydraulic cement for retro-filling and perforation sealing procedures of bi- and tri-furcated teeth. Presently it has been used as apexification inductor,[3] as a pulp protector and in pulp-capping techniques.[4-6] MTA is composed of

* DDS Medical Naval School, Graduate School, Frigate Lieutenant.
§ Dental Biomaterials Laboratory, Graduate and Research School, Faculty of Dentistry, National Autonomous University of Mexico (UNAM).

Received: July 2016. Accepted: January 2017.

This article can be read in its full version in the following page:
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80% Portland cement and 20% Bismuth trioxide (Bi_2O_3) which is incorporated to provide cement with radio-opacity properties as well as rendering easy to identify in an x ray. Success of an endodontic material is directly dependent upon its sealing capacity. This sealing capacity in turn depends on several factors such as placement, setting time and solubility. Multiple studies have been conducted to verify MTA sealing and comparison with IRM (intermediate restorative material) amalgam and glass ionomer.[7-9]

Glass and bioactive ceramic materials have been developed as a response to the need to eliminate interfacial mobility in implanted bio-inert ceramics. In 1971 Hench showed for the first time that a man-made material could bond to bone. Bioglass® was the first bioactive glass material to be developed.[10-12] It has been proven that this bioactive glass possesses anti-bacterial properties,[13,14] whereas bioactive ceramics such as wollastonite ($CaSiO_3$) have been studied as materials to manufacture artificial bone and dental applications.[15,16] A common characteristic of bioactive ceramic and glass material is the fact that they form a biologically active apatite coating which provides a bonding interface with tissues.

It has been observed that when adding these materials in different percentages, setting time can significantly decrease, thus decreasing material´s solubility.[17] An ideal retro-filling material must be easy to handle, non-cytotoxic, biocompatible with adjacent tissues, possess nil or low solubility and be dimensionally stable in order to avoid fractures or leakage associated to volumetric alterations. It is well known that solubility is related to material's leakage, thus decrease in setting time and solubility could elicit micro-leakage decrease. The target of the present study was to measure leakage in a MTA –type dental cement modified with wollastonite and bioactive glass.

MATERIAL AND METHODS

MTA Angelus (Angelus®, Dental Products Industry, Londrina Brazil) was used as control for the present study. MTA EX is composed of white Portland cement (CPO40B Cruz Azul, Mexico) previously characterized,[18] with aggregation of 20% wt bismuth trioxide to provide radio-opacity. Once MTA Exp cement was achieved, wollastonite was added (NYCOMEX, Hermosillo, Sonora, Mexico) in percentages of 10, 20 and 30% wt, in order to form groups WEO10, WO20, and WO30 respectively. Finally, three additional groups were formed based upon addition of bioactive glass in the same percentages as those mentioned for MTA Exp, thus forming groups *BV10*, *BV20*, and *BV30* respectively. Before adding bioactive materials, wollastonite was grounded in a ceramic mill, bioactive glass was ground in a zirconium mill. Both aggregates were sieved in order to obtain a particle size lesser than 50 μm.

Microfiltration

Microfiltration tests were conducted according to methodology reported by Islam;[19] 60 permanent teeth were used, these teeth should not have been extracted for more than 3 months and were stored in 4 ºC water until usage. Teeth required the characteristic of being single-rooted, with straight root and closed apex. Initial dental X rays were taken in order to ascertain the presence of a single canal. With a diamond disc, clinical crowns were sectioned underneath the enamel-cement junction. Instrumentation was initiated with a number 15 file, cutting down 1 mm from total length obtained from a reference point. Canals were prepared with a crown-down technique with balanced forces, by means of manual and rotary instrumentation with Protaper rotary system (rotary protaper universal system, Dentsply, Switzerland) in order to obtain a diameter standardized to a #40 master apical file. Canal irrigation was achieved according to the following protocol: between each file change, 2 mL, 2.5% ultrasound activated sodium hypochlorite was used as well as 0.5 mL of 17% ultrasound activated REDTA (Varios 350 Lux, NSK Japan) for 15 seconds for each solution, after this, 2 mL physiological serum and 2 mL alcohol were applied.

After this and with a diamond disk, with an ultrasound tip, 3 mm were cut from the apex in a perpendicular position to the tooth´s longitudinal axis; With an ultrasound tip (E32D tip and Endo-Mate DT, NSK Japan) 3 mm deep retro-cavities were prepared in the apical cut area, where each one of the cements were placed. A second series file was adapted in order to avoid that cement coming from the retro-fillings would extend through the canal. Once cement retro-fillings were placed, teeth were placed in glass vials with de-ionized water for 24 hours, so as to allow the cements to set. Roots were covered with two layers of varnish, excepting 2 mm from the apical end; apical extremity was immersed in a 2% methylene blue solution for 24 hours.

Two additional groups were established: one for positive control with leakage (non filled) and another for negative control without leakage (totally covering the root with varnish) *(Figure 1)*. After this time, teeth were rinsed with water in order to remove excess ink, and were left to dry for 10 days. After this, all teeth were longitudinally trimmed with a millimetric trimmer and diamond disk. Teeth were paralleled in order to be observed in a 20x optical microscope. Microscope possessed an eyepiece with a graduating mesh in order to measure leakage millimeters in each one of the samples *(Figure 1)*.

Statistical analysis

Data were collected and captured in SPSS version 20 for analysis. Kolmogorov-Smirnov test was conducted to prove data normalcy, parametric tests were then conducted. ANOVA test was applied, as well as Dunnet Post Hoc, with confidence interval of 95%.

RESULTS

Figure 2 shows mean values of microleakage test results. It can be observed that MTA Exp cement exhibited lesser leakage with a 0.66 mm average, whereas WO10 groups exhibited greater filtration with 1.61 mm average.

It was observed that in the case of cements with wollastonite and bioactive glass aggregates, microleakage decreased according to percentage increase of the aggregate. In the experimental group with bioactive glass, greater microleakage stability was observed, with a range of 0.81-0.96. The group with wollastonite aggregate exhibited more visible changes in this property, decreasing from 1.61 mm to 0.99 mm. MTA Angelus used as control exhibited 0.71 mm microleakage. Statistically significant differences were found with 95% reliability.

DISCUSSION

Effects of bacterial microleakage on dentin-pulp complex is well established. Its prevention is of the utmost importance, therefore, within modifications undertaken in MTA cements have mainly been with the addition of different materials such as calcium chloride[20,21] with the aim of decreasing setting time. Some authors have observed that incorporating bioactive glass into glass ionomer cements modifies setting time,[22,23] this is also the case when glass ionomer is incorporated into MTA type cements.[17] Solubility is an important characteristic to be avoided in dental use materials, since there is an association of greater solubility with lesser sealing and greater

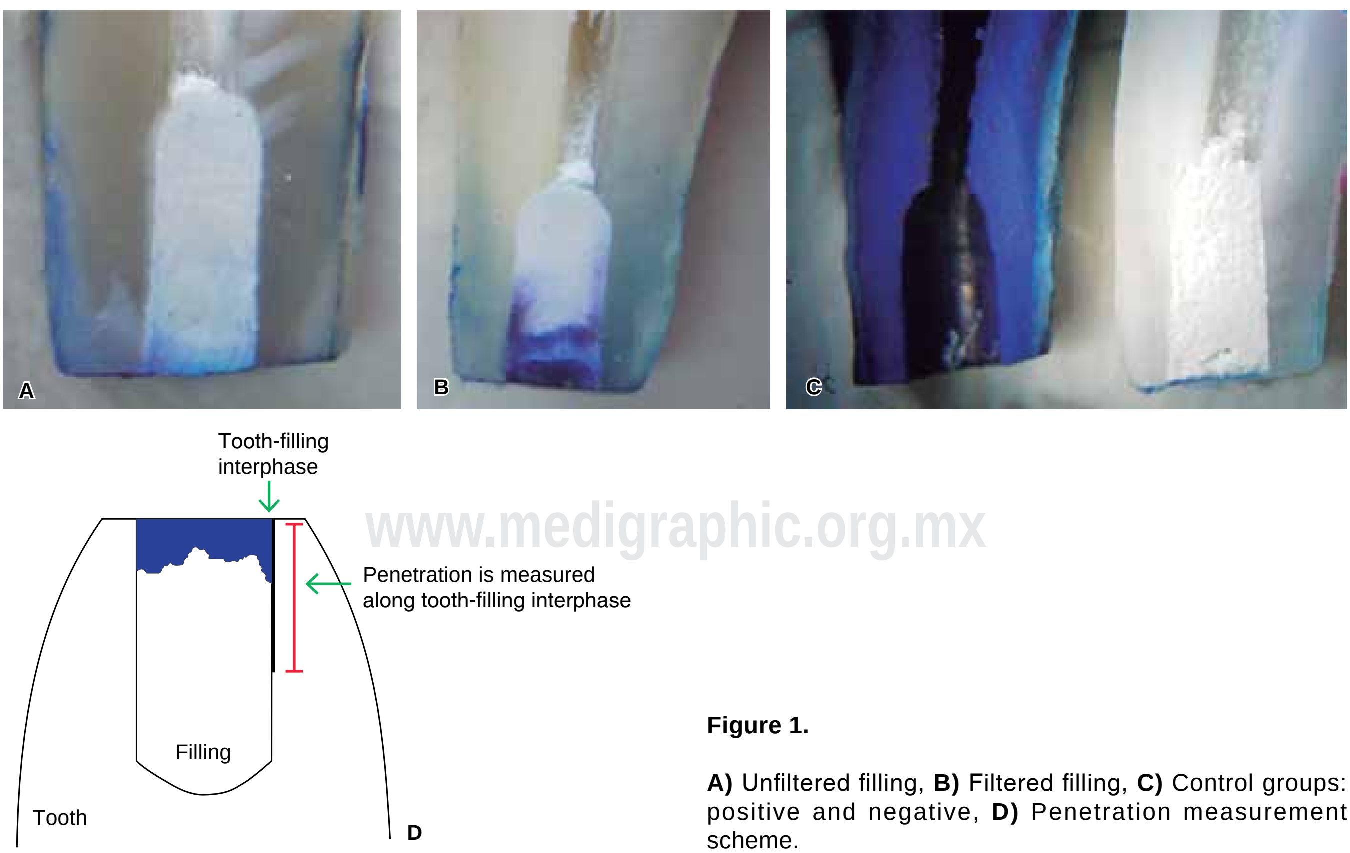
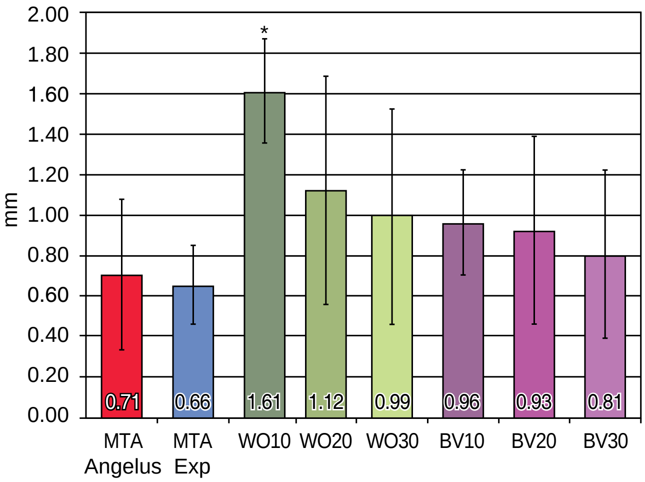


Figure 1.

A) Unfiltered filling, **B)** Filtered filling, **C)** Control groups: positive and negative, **D)** Penetration measurement scheme.



Average is shown in the upper section of the name, bars represents standard deviation. MTA Angelus was used as control. Statistically significant differences were found with group WO10 (ANOVA $p < 0.001$, Dunett $p < 0.001$ $n = 10$).

Figure 2. Microleakage.

leakage of fluid and bacteriae. This property is affected by the powder-liquid relationship during cement preparation. Fridland[24,25] showed that MTA solubility and porosity increased with amounts of liquid, therefore, powder-liquid ratio was standardized in the present study (1 g powder - 0.33 g water).

Some of the factors to be taken into consideration when choosing a retro-filling material are: short setting time, that it should not to be affected by humidity, low or nil solubility, suitable dimensional stability and avoidance of bacterial or fluid leakage. Several studies have evaluated MTA microleakage and sealing. Islam[19] found that grey MTA ProRoot® and grey Portland cement were materials suffering lesser leakage, when they were assessed with methylene blue methods, since they exhibited an average of 1.63 and 1.62 penetration. We confirmed these findings since our cement formulations exhibited a range of 1.6 to 1.66 mm of dye penetration.

M Torabinejad[26] mentioned that ideal cavity depth for retro-filling should be between 3 and 4 mm, in order to prevent presence of apical deltas which might lead to treatment failure. It is worth noting that all formulations allowed dye passage; this can be explained bearing in mind they are materials which set in the presence of humidity, and that, when in contact with bodily fluids, somehow involve environment's humidity, that is to say, they can absorb water, blood or tissue fluids until completing hydration and setting processes, absorbing thus part of the methylene blue solution.

Barthel[27] conducted a comparative study between bacterial leakage and dye leakage (methylene blue), he reached the conclusion that the molecular size of the penetrating agent (bacteria or dye) was not a relevant parameter to evaluate sealing, whereas Souza[28] did find differences when using two dyes such as methylene blue and rhodamine.

Some articles mention that dye microleakage is not reliable since some physical mechanisms such as diffusion and capillarity are not taken into account.[29] It has been observed that some techniques to assess microleakage such as dye penetration, fluid filtration method and electrochemical method do not exhibit correlation in their results, even though the same materials are examined.[30] There are techniques such as passive penetration, active penetration centrifugation, and vacuum application in passive penetration where statistically significant differences have been found when compared to the technique used for dye penetration,[31] therefore, physical effects elicited in the method must be taken into account since they can directly affect obtained results.

CONCLUSIONS

According to limitations inherent to the present study we can conclude that microleakage decreases when greater amounts of bioactive materials are incorporated.

Use of complementary techniques conducted with scanning electron microscope is suggested to measure microleakage, in addition to assessing marginal adaptation of cements to the dentin wall.

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Mailing address:
Abigailt Flores-Ledesma
E-mail: dra_abyfl@hotmail.com