Effect of the immersion moment at the volumetric alteration of the mineral trioxide aggregate HP

Lyz Cristina Furquim **CANALI**[1]
Rafaela Fernandes **ZANCAN**[1]
Rodrigo Ricci **VIVAN**[1]
Mario **TANOMARU FILHO**[2]
Marco Antonio Hungaro **DUARTE**[1]

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ABSTRACT

Introduction: Solubility is a property related to the dissociation of the constituents of the material by the action of contact with the surrounding liquid, for this reason, the aim of this study was to evaluate the effect of the hydration during the scanning in the microtomography on the volumetric alteration of the MTA HP. **Methods:** Twenty acrylic teeth upper incisor with retrograde cavity were utilized. The MTA HP cement was inserted into the cavity using a Paiva condensor. The specimens were visually inspected with a 5x magnifying glass to ensure they did not remain void or gaps. The specimens were divided into 2 groups (n=10). The teeth were scanned shortly after handling the MTA. For the group with water immersion, hydrated Eppendorf was kept with 1mL the water during the scanning and the other group, the teeth were scanning without water. In the two groups the teeth were immersed into water during 7 days. Next the teeth were newly scanned in the Micro-CT using the same parameters and conditions of each group. Reconstruction of images by the Nrecon software and the solubility volume determined by the CTan, analyzing the volumetric change. **Results:** The group of specimens scanned immersed into the water presented higher volumetric change with statistically significant differences in relation the group scanned without immersion. The scanning of the specimen immersed in water favors the greater volumetric loss of the material. **Conclusion:** Studies to evaluate volumetric change of calcium silicate cements should be made immersed in water.

Keywords: Solubility. Root Canal Obturation. Physical and Chemical Properties.

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[1] Universidade de São Paulo, Faculdade de Odontologia de Bauru, Departamento de Dentística, Endodontia e Materiais Odontológicos (Bauru/SP, Brazil).

[2] Universidade Estadual Paulista "Júlio de Mesquita Filho", Faculdade de Odontologia de Araraquara (Araraquara/SP, Brazil).

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Contact address: Lyz Cristina Furquim Canali
E-mail: lyzfurquim@gmail.com

Introduction

Several studies have analyzed the physicochemical properties of endodontic and retrograde filling materials.[1-5] Recently a study correlated the results of physicochemical properties usually obtained by standard tests with the results obtained by tests using new methodologies such as micro-CT.[6]

The proposed tests with Micro-CT complemented the conventional tests, allowing three-dimensional data to be obtained, perfecting the tests recommended by ISO standards and representing standardized and reproducible methods.[1-4,7] Generally, in vitro tests evaluating the properties of solubility and volumetric change have been done according to the specifications of ANSI/ADA n57 or ISO 6876. These standards are based on the difference in weights before and after contact with distilled water.[5,8-11] However, this study followed the methodology based on the volumetric change obtained from the digitalization of three-dimensional images of the specimens obtained by micro-CT.[5,12] This methodology has a great advantage because it evaluates only the radiopaque material, thus excluding the water under analysis, which is a factor that must be considered, since MTA is hydrophilic cement. The specimens simulated the clinical aspect in better shape and allowed the data to be compared with those of other studies that have used retrograde material in cavities of replicas of natural teeth.[4,12,13]

Solubility is a property directly related to the dissociation of the constituents of the material by the action of contact with the surrounding liquid. Thus, the larger contact area, as found in samples tested according to the ISO standard, increases the possibility of greater solubility. Furthermore, analysis performed after periods of immersion in distilled water complements evaluation of the solubility of the materials, and allows greater understanding of the dimensional behavior and solubility of the materials in periods longer than 24 hours.[7,14] As shown in the studies that performed the solubility or volumetric change tests using blocks with retrograde cavities, the teeth were scanned by micro-CT but without being in contact with water, and normally the material heave the setting without coming into contact with humidity.

However, these studies did not evaluate the solubility or volumetric change during the setting time of the material. Please note that no studies were found, which evaluated whether scanning with the teeth immersed in water interfered in the volumetric change of the material. Therefore, the aim of this study was to verify and compare whether scanning the specimens immersed in distilled water would influence in the volumetric change (solubility), thereby reproducing a situation closer to that of the surgical or perforation site, due to local humidity at all times.

Materials and methods

Obtaining Specimens

The white MTA HP cement (Angelus, Londrina, PR, Brazil) was manufacturer recommends 1 package of MTA REPAIR HP and 1 drop of the liquid. Twenty acrylic teeth, replicas of a central maxillary incisor were made and retrograde cavities with 1012 standardized spherical drill bits with 3 mm of deep were performed and filled with MTA cement using an operating device such as the Paiva condenser. The specimens were visually inspected with a 5x magnifying glass to ensure they did not contain void or gaps. The specimens were divided into 2 groups (n = 10) according to the immersion in water, or not during the scanning procedure by Micro CT.

Solubility analysis

To determine the solubility of the groups, after filling specimens were immersed in glass vials containing 10 ml of distilled water. The teeth were scanned immediately after handling the MTA. Group 1 was kept in hydrated Eppendorfs during the scanning, while the replicas of Group 2 were also in eppendorfs but these without water and then were scanned without immersion in the water. The solubility was measured volumetrically by a microcomputer from the tomographic images. The samples were scanned using a microfocus CT scanner (SkyScan 1174v2; SkyScan, Kontich, Belgium). The scanning parameters were determined using 50 kV of X-ray tube voltages, 800 μA of anode current, a voxel size of 14.1 μm with 1,1° pitch of rotation and 360° rotation. Digital data with 1024 x 1304 pixels were compiled by the reconstruction software (NReconv1.6.4.8, SkyScan), and the software (CTan CTan v1.11.10.0, SkyScan) was used for volume measurements. For each sample, a binary value was adjusted and through the 3D plug-in the analysis the total volume (mm^3) was recorded. After the first readout, the samples were immersed

in glass vials containing 10 mL of distilled water and then stored at 37 °C for 168 h. Subsequently, the samples were scanned again using exactly the same parameters and conditions as those used in the first scan, and the volume was analyzed again. The results were converted into solubility percentages. The values were subjected to the Shapiro-Wilks test to evaluate the normal distribution. Due to absence of normal distribution, the intra-group comparison was made by using the Wilcoxon test, and for comparison of the percentage of volumetric change between the groups, the Man-Whitney test was used. The significance level was 5%.

Results

The two groups presented statistically significant differences between the initial and final volume ($P<0.05$). The group scanned immersed in the water presented higher volumetric change values with statistically significant differences in comparison with the group scanned without immersion in water ($P<0.05$) (Table 1).

Figure 1 shows the representation of the three-dimensional solubility reconstructions after the initial and final volume micro-CT scans of Group 1 immersed in water and of Group 2 without immersion in water.

Table 1. Median, minimum and maximum values of the initial volume, final volume and percentage solubility after 7 days in the studied groups.

	Initial volume	Final Volume	% Solubility
Water immersion	0.52 (0.21-0.94)[a]	0.39 (0.06-0.70)[b]	23.5 (0-70.07)[A]
Without water immersion	1.43 (0.16-1.83)[a]	1.33 (0.16-1.77)[b]	1.55 (0-13.73)[B]

Different lowercase letters show the statistically significant difference between the initial and final volumes in the intra-group comparison ($P<0.05$). Different Capital letters show statistically significant differences in the percentage of volumetric change in the comparison between the groups.

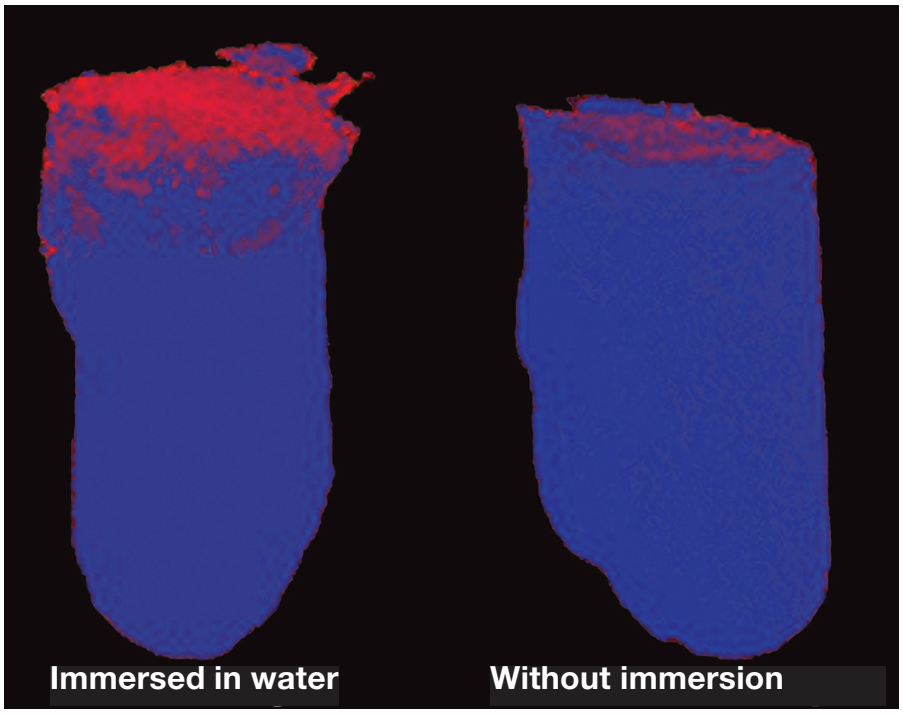

Figure 1. Shows the representation of the three-dimensional solubility reconstructions after the initial in blue color and final volume in red color micro-CT scans of Group 1 immersed in water and of Group 2 without immersion in water.

Discussion

The volumetric change of root end and perforation sealing materials is an important property, since dissolution of the material can allow infiltration, compromising the success of the treatment. In vitro tests evaluating the properties of solubility or volumetric change have used the ANSI/ADA n57 or ISO 6876 specifications, which are based on the difference between the weights before and after the placement of the cement in distilled water.[1-3,7,10] However, hydrophilic material can absorb water and increase in weight without adequately demonstrating its solubility. Another point is that in the cited methodology, the material is tested after setting and it does not demonstrate the solubility during setting.

The present study followed the methodology based on the volumetric change obtained from the digitalization of three-dimensional images of the specimens by micro-CT.[5,10,11] This methodology has a great advantage because it only evaluates the radiopaque material, thus excluding the water under analysis, which is a factor that must be considered because MTA is a hydrophilic cement. Another point is that the specimens used presented similarity with the clinical aspect, allowing the data to be to compare with those of other studies that used the root end filling material in cavities in replicates of natural acrylic teeth.[3,12,13]

New methodologies such as micro-CT can be used to analyze physical-chemical properties of endodontic types of cement and root end filling materials relative to dimensional change.[11-13,15] The use of Micro-CT in the present study allowed the volumetric analysis (in mm^3) of the materials, and showed the dimensional change. Furthermore, analysis after the periods of immersion in distilled water complemented evaluation of the solubility of the materials and allowed greater understanding of the dimensional behavior and solubility of the materials in periods longer than 24 hours. The images were acquired using microtomography, allowing the use of the same specimen in different periods of analysis. The protocols developed using Micro-CT to evaluate the filling capacity of the materials allowed a three-dimensional analysis of the filling percentage from the empty cavity.[15]

However, in the other studies[12,16-22] the scanning was performed with the material without it coming into contact with the liquid. Thus, during the first hour, which is the time taken to perform scanning, the material was without contact with moisture and consequently it did not have the effect of solubilization. Hydration of the MTA cements and calcium silicate results in reduction of the space for solubilization and precipitation of hydrated compounds. There is growth and consequent densification of the matrix of these products, probably due to the precipitated surface crystals that are released from di- and tricalcium silicate-containing materials, and these avoid a further increase in solubility.[11,23,24] Porosity occurs because of spaces in the non-hydrated cement,[23] and the porosity and solubility of materials may affect their stability, integrity, and durability.[24] The porosity may be visually determined by observing the size and distribution of pores in the polished surface of cements.[11] However, comparing the volumetric change with hydration and processing the actual state is important.

The aim of this study was to verify and compare the volumetric change during the scanning procedure by micro-CT with the specimens immersed or not in distilled water. The results of the present study showed that the scanning of the material immersed in water significantly increased the volumetric loss of the material, demonstrating that the higher volumetric change values occurred during the setting of the MTA HP. Probably the scanning with the specimen immersed in water favored greater reactivity and formation of Portland (Calcium hydroxide), which is a soluble component.[25] The majority of the studies in the literature were conducted without the ideal reproduction of moisture, which influenced the solubility test, therefore it is suggested that in new studies that will be using this methodology, the specimens should be immersed in water during the scanning procedure.

Conclusion

The scanning of the specimen immersed in water favors the greater volumetric loss of the material. Studies to evaluate volumetric change of calcium silicate cements should be made immersed in water.

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