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Comparison of the apical seal on filled root canals with Topseal® vs MTA Fillapex® sealers: A quantitative scintigraphic analysis

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ABSTRACT

This study investigated the microleakage of two different root canal obturation systems, using the nuclear medicine approach, with sodium pertechnetate ^{99m}Tc. Twenty six single-rooted extracted teeth were selected. The crowns were sectioned to obtain 15 mm long root segments and each tooth was prepared using rotary ProFile® instruments. The roots were divided into 2 experimental groups and two control groups. Twenty root canals were filled, using Thermafil® and Topseal® or MTA Fillapex® as a sealer. On the 7th and the 28th day the apices were submersed in a solution of ^{99m}Tc-Pertechnetate during 3 hours. The radioactivity was counted using a gamma camera. Although apical leakage on the 7th day in the Topseal group was reduced compared with RealSeal1, with a statistical significant difference (p = 0.057), on the 28th day, the MTA Fillapex increased the sealing properties (p = 0.017).

Keywords: Microleakage; Nuclear Medicine; Obturation; Thermafil; Topseal; MTA Fillapex

1. INTRODUCTION

It has been established that apical periodontitis is a disease caused by bacteria derived from the root canal [1,2]. The first stage of root canal therapy is microbial control, followed by root canal filling. Microbial control includes removal of the protein degradation products, toxins, and mainly bacteria [3]. Chemical irrigants are essential for successful debridement of root canals, during shaping and cleaning procedures which should expose the collagen networks. It has been shown that the removal of the organic phase from the mineralized dentine by NaOCl enhances dentin permeability to EDTA [4,5]. Additionally, removal of the smear layer has been recommended to reduce microleakage and improve the fluid-tight seal of filled canals [6,7].

The root canal filling must seal the canal space both apically and coronally and the most commonly used material for root canal obturation is gutta-percha combined with a sealer. Gutta-percha is considered an impermeable core material but does not bond to the root dentin walls. As well as the obturation technique, the use of a sealer is essential to obtain a fluid-tight seal between the dentinal wall and the core obturation material.

There are several different sealers available such as zinc oxide eugenol, calcium hydroxide, resin based, glass ionomer, and silicone.

Resin sealers, like TopSeal® have a long history of use to provide adhesion and showed diminished leakage over time, which can be explained by the slow setting properties of this material.

The absence of endodontic sealers with ideal properties has encouraged the development of a large range of materials, including MTA Fillapex® (Angelus Indústria de Produtos Odontológicos Ltda, Londrina, Brazil) that attempt to take advantage of the biological and sealing properties of mineral trioxide aggregate (MTA), [8]. MTA Fillapex® is a sealer presented in a paste/paste system and, apart from MTA, is composed of resins, bismuth oxide, silica nanoparticles, and pigments.

To date, several studies have evaluated the outcomes of different root canal sealers with various leakage models [9-11].

The use of sodium pertechnetate (^{99m}TcNaO4) in nuclear medicine is well established and the evolution of

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diagnostic conventional nuclear medicine can be mainly attributed to the existence and the chemical versatility of this radionuclide [12,13].

Considering all the ^{99m}Tc characteristics and considering that Nuclear Medicine is an approach with high sensitivity and specificity, radionuclides may provide quantitative and objective results concerning infiltration.

Thus, the aim of this study was to use nuclear medicine methodologies to assess microleakage of the root canals. For that purpose we compared the sealing ability of roots filled with Topseal as a sealer and Thermafil, with those that were filled with Thermafil and MTA Filapex as a root canal sealer, using the $^{99m}TcNaO_4$.

2. MATERIAL AND METHODS

Thirty one extracted human premolar teeth, with a single root and a single canal with the apex completely formed, were used in this study. These teeth were stored until use in a 0.9% sodium chloride solution containing 0.02% sodium azide at 4˚C, to prevent bacterial growth.

The crowns were sectioned with a high-speed bur and water spray, in order for all the roots to be approximately 15 mm long. Canal length was determined by inserting a K file, ISO size #15 (Dentsply Maillefer, CH-1338 Ballaigues, Switzerland) into the canal until its tip was visible at the apical foramen. The working length was established 1 mm short of the apex.

Instrumentation of the root canals was performed with a crown-down technique using Protaper® nickel-titanium rotary instruments (Dentsply Maillefer, CH-1338 Ballaigues, Switzerland). The handpiece was used with an electric engine (X-Smart; Dentsply Maillefer, CH-1338 Ballaigues, Switzerland) at 250 rpm. Instrumentation was completed with Protaper F3 instruments up to the working length. After the use of each instrument, the canals were irrigated with 3 mL of 2.5% NaOCl by using a 27-gauge Monoject irrigation needle (Sherwood Medical, St. Louis, MO). The final rinse was performed using 3 mL of 2.5% NaOCl for 3 min and 17% EDTA for 3 min, (Pulpdent Corporation, Watertown, MA) followed by 3 mL of saline solution for 1 min, to neutralize the EDTA. At the end, the roots were randomly divided into 2 experimental groups of 10 teeth each (group 1 and 2) and two control groups of 6 teeth designated control groups. In group 1 the obturations were performed with TopSeal® sealer placed into the canal using a F3 master point. Then, the Thermafil® carrier points F3, was inserted in the canal after being thermo plasticized in the ThermaPrep oven (Dentsply Maillefer, CH-1338 Ballaigues, Switzerland), according to the manufacturer's instructions.

In group 2, the obturations were performed by using MTA Fillapex® sealer placed into the canal using a F3 master point. Then, the Thermafil® carrier points F3, was inserted in the canal after being thermo plasticized in the ThermaPrep oven (Dentsply Maillefer, CH-1338 Ballaigues, Switzerland), according to the manufacturer's instructions. The excess of gutta-percha, in both groups, was removed with a hot instrument, and then the root canal orifices were sealed using a flowable resin composite (Versite Flow, Kerr SA, 6934 Bioggio, Switzerland).

All experimental procedures were carried out by the same endodontist.

After the filling procedures, two radiographs were taken in orthoradial and proximal views, to analyze the quality of the canal filling.

The filled root segments were stored for 1 week at 37˚C and 100% relative humidity to allow the sealers to set completely, before leakage evaluation with a nuclear medicine approach.

Finally concerning group 3, the positive control group (n = 6), procedures for selection and instrumentation were the same as those described for the experimental groups, except that the prepared root canal space was not obturated.

Evaluation of Leakage

For leakage determination, the roots of the experimental and positive control groups were covered by two layers of nail varnish, except 2 apical mm. In the negative control group, the entire root surface, including the apical foramen was covered by the nail varnish. The teeth were suspended in Eppendorfs, containing $^{99m}TcNaO_4$ remaining in contact with the solution for three hours. After this period the roots were dried on absorbent paper and then the varnish was removed. The scintigraphic images were made for each tooth using a gamma camera (GE 400 AC, Milwaukee, USA). For each tooth a static image was acquired for three minutes for a 512 × 512 matrix size (**Figure 1**). Regions of interest (ROIs) in each image were drawn over each tooth, to obtain the total counts and the counts per minute (cpm). All the nuclear medicine procedures were made by one nuclear medicine specialist, in a blind way. The procedure was repeated at the 7th and 28th days.

The statistical analyses were performed using the Mann-Whitney test for comparison the groups and between time in each group, the Wilcoxon test, given the size of each group. Statistical significance was assessed using α = 0.05, using statistics software (SPSS version 19, Japan Inc., Tokyo, Japan).

3. RESULTS

The means and standard deviations of ROI (cpm), from the specimens at the 7th and 28th days after obturation are given in **Table 1**. In group 1, (Thermafil®/TopSeal®), it was found that over time, the number of counts de-

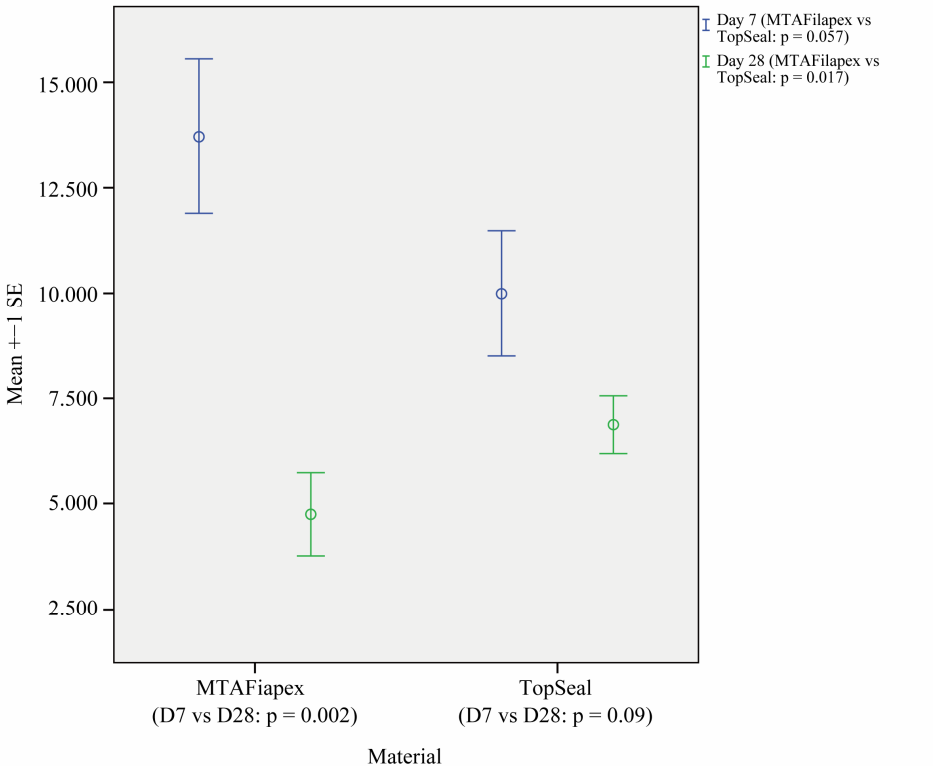

Figure 1. Comparison the sealers, on the 7th day the Topseal had less leakage than MTA Fillapex (p = 0.057), but on the 28th day the MTA Fillapex had less leakage than Topseal, with statistically significant difference (p = 0.017).

Table 1. Means and standard deviation of regions of interest (ROI)/counts per minute (cpm), from the specimens at the 7th and 28th days after obturation.

Material	Time (Days)	n	Mean (cpm)	SEM (cpm)	Min (cpm)	Max (cpm)	P25	P50	P75	D7 vs D28
MTA Fillapex	D7	13	13722.85	1829.47	8844	34288	9758.50	12849.00	14538.00	Mann-Whitney p = 0.002
	D28	13	4745.15	977.559	1873	14948	2133.50	3622.00	5925.50	
Topseal	D7	12	9992.50	1490.30	4360	19246	5293.75	8458.00	12750.75	Mann-Whitney p = 0.099
	D28	12	6877.75	683.024	4046	11756	5232.75	6575.00	8791.50	
MTA Fillapex vs Topseal	D7	Wilcoxon (p = 0.057)								
	D28	Wilcoxon (p = 0.017)								

creases between the two times, the 7th and 28th days with 9992.50 and 6877.75 cpm respectively. These differences are statistically significant (p = 0.009; **Table 1**).

In group 2, (Thermafil®/MTA Filapex®) it was found that over time there are significant differences between the counts obtained at the different times, the 7th and 28th days: 13722.85 and 4745.15 cpm respectively, with statistical significance (p = 0.002; **Table 1**) (**Figure 1**). Comparing the sealers, although on the 7th day the Topseal had less leak- age than MTA Fillapex®, with statistically significant dif- ference (p = 0.057), on the 28th day the microleakage on Topseal® decrease, but MTA Fillapex® had less leakage, with statistically significant difference (p = 0.017).

4. DISCUSSION AND CONCLUSIONS

The analysis of the sealing ability of new root canal obturation systems is important, in both the coronal and apical leakage, because they have been cited as a significant cause of post treatment disease [10,11].

Although a bacterial leakage model may appear to be more clinically relevant compared with a fluid infiltration model the latter technique was used here [14].

The dye penetration technique is one of the most common methods for the investigation of apical leakage because of the simplicity of laboratory procedure and final reading of the results [15,16].

Although the fluid transport model and bacterial penetration has been widely used to determine leakage around coronal restorations and endodontic retrograde fillings (Wu *et al.* 1993) and it has been proven to be more sensitive compared with the conventional dye penetration, the radionuclide methods are not usually used [17].

Our option and the principal advantages of using a radioactive probe with $^{99m}TcNaO_4$ is that this radionuclide method is nondestructive, and is a quantitative method that enables measurement of microleakage from the same specimens at intervals over extended periods. This procedure is important for the study of interfaces; artifacts may occur due to the cutting section process at the surface level with other methods, but this does not occur with radionuclides and it is possible to evaluate the leakage over extended periods.

Thermafil® is an obturation method with simplicity and short execution time, and according to the manufacturers its usage confers a good seal. According to Ugur *et al.* (2007), obturation with systems carriers has a smaller deviation in the values of leakage compared with vertical and lateral condensation, which can be a good indicator to provide a correct method for use in the clinic [16].

Because an appropriately filled canal requires an appropriate cleaning and shaping procedure, a F3 rotary file was used at 1 mm from the foramen, because clinical antimicrobial efficacy using this diameter has been reported [17].

MTA Fillapex® is mainly composed of a combination of resins, silica, and MTA. Similarities related to resin-based sealers and some differences on the physical properties of the original MTA formulation are expected for MTA Fillapex®, in spite of its favorable biological features and ability to release calcium ions [8]. Thus, the similarities between MTA Fillapex® and Topseal® regarding bond strength, pattern of failure, and handling characteristics are also corroborated by the sealers composition.

Accordingly, epoxy resin-sealers can be considered the gold standard material for testing endodontic sealers, because previous studies have pointed out that it presents advantages in comparison with other materials usually used as provide adhesion and showed diminished leakage over time, which can be explained by the slow setting properties of this material [18].

Although the manufacturer claims that MTA Fillapex provide a good seal due the expansion during setting, there are limited independent publications about the physicochemical properties and the possibility to use, in clinical practice.

The findings of this study demonstrated that on the seventh day, specimens filled with MTA Fillapex® leaked more than specimens filled using Topseal®, but on the 28th day, Topseal® leaked more than specimens filled using MTA Fillapex®.

It may be concluded that sealers with MTA reduce the leakage to the root canal walls over time, which can be attributed to the volumetric change after decomposition of components.

Under the experimental conditions of the current *ex vivo* experiment, the results demonstrated that MTA Fillapex® has the potential to capitalize on the biological and sealing characteristics of MTA and, at the same time, improve its flow rate and manipulation characteristics. Nevertheless, further investigation to clarify other physical properties of this new material and other features of root canal sealers is required.

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