

Evaluation of apical marginal leakage in teeth retrofilled with MTA-water and MTA-Fillapex: a study in avulsed teeth

Antonio Henrique **BRAITT**¹
 Camila Almeida **ANDRADE**²
 Ana Grasiela da Silva **LIMOEIRO**²
 Yanessa Santos **MUNIZ**³
 Carlos Eduardo da Silveira **BUENO**⁴

doi: <http://dx.doi.org/10.14436/2178-3713.5.1.030-039>

ABSTRACT

Introduction: Since periapical surgical therapy success depends on adequate apical seal, MTA has been recommended as the best retrofilling material.

Objective: To assess whether the association between MTA and Fillapex sealer negatively affects the material apical sealing ability. To this end, apical leakage was tested with 1% rhodamine B was used. **Methods:** Fifty roots with straight canals were prepared by means of the ProTaper Universal system up to F5 instrument, and filled by means of the modified McSpaden technique. Specimens were divided into four groups: G1, G2 and G3 were subjected to apicoectomy and retropreparation with ultrasonic tip; whereas G4 did not undergo either apicoectomy nor retropreparation, and served as control.

G1 was retrofilled with MTA-water, G2 was retrofilled with MTA-Fillapex, and G3 was not retrofilled, thereby serving as negative control. The roots of G4 received two coats of red nail polish, whereas the roots of G1, G2 and G3 were also coated, except in the region where apicoectomy was carried out. Specimens were immersed in 3 ml of 1% rhodamine B for 8 days and stored in an incubator at 37 °C and 100% humidity. In order to have microleakage assessed, the specimens were longitudinally cleaved, photographed and sent to three specialists in Endodontics who analyzed four levels of leakage: zero; 0-1 mm, 1-2 mm and 2-3 mm. **Results:** Results reveal that the MTA-Fillapex association had less leakage than MTA-water.

Keywords: Endodontics. Oral surgery. Dental leakage.

How to cite this article: Braitt AH, Andrade CA, Limoeiro AGS, Muniz YS, Bueno CES. Evaluation of apical marginal leakage in teeth retrofilled with MTA/water and MTA/Fillapex: a study in avulsed teeth. *Dental Press Endod.* 2015 Jan-Apr;5(1):30-9. DOI: <http://dx.doi.org/10.14436/2178-3713.5.1.030-039>.oar

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

¹Professor, Specialization program in Endodontics, FUNORTE, Divinópolis, Minas Gerais, Brazil.

²Masters student in Endodontics, São Leopoldo Mandic, Campinas, São Paulo, Brazil.

³Specialist in Endodontics, FUNORTE, Divinópolis, Minas Gerais, Brazil.

⁴Professor, FUNORTE, postgraduate program in Endodontics, Divinópolis, Minas Gerais, Brazil.

⁵Full Professor, São Leopoldo Mandic, Campinas, São Paulo, Brazil.

Submitted: November 17, 2014. Revised and accepted: January 30, 2015.

Contact address: Antonio Henrique Braitt
 E-mail: henrique_braitt@terra.com.br

Introduction

Current concepts that guide endodontic treatment emphasize cleaning and shaping of the root canal system, in addition to the use of biocompatible material and techniques employed for three-dimensional filling, which enables high success rates to be achieved in endodontic therapy. Nevertheless, in some cases, due to pathological processes, degenerative changes, anatomically unfavorable teeth, impaired endodontic access and iatrogenesis, the dental organ may be preserved by means of periapical surgery, only.¹

Surgical procedures include apicoectomy with retrograde filling, which consists in cutting the apical portion of a tooth root, followed by preparation of cavity in the final portion of the remaining root and filling of this space with adequate material.² According to Tanomaru Filho et al,³ the material of choice should have good physicochemical and biological properties, so as to provide proper seal and satisfactory biocompatibility.

A number of different types of material have been studied, for instance, amalgam, super-EBA, glass ionomer, calcium hydroxide, composite resin, and mineral trioxide aggregate (MTA), a dental material that, according to research, presents with promising results.^{4,5,6}

A wide variety of tests is available; however, according to Wu and Wesselink,⁷ the sealing ability of a given material is usually assessed by leakage experiments, whether apical or coronal. Nevertheless, there is no standardization, which leads to significant difficulty discerning between different literary findings.

Considering that surgical therapy success relies on adequate apical seal, MTA is definitely the best option for retrofilling. However, due to difficulties handling it, the need for prior training, and the high costs involved, it is of paramount importance to assess marginal leakage in retrofilling procedures carried out with MTA associated with Fillapex, particularly with regard not only to potential changes in the material properties and characteristics, but also to the quality of apical seal, all of which are key to endodontic therapy success.

Material and methods

A total of 50 freshly extracted human single-rooted teeth with intact roots, 26 upper incisors and 24 upper canines, provided by Universidade Estadual de Feira de Santana Tooth Bank, were used. The teeth were stored in 1% thymol (Aquamarine, Porto Seguro, Bahia, Brazil)

until research onset. Subsequently, they were immersed and kept in 2.5% sodium hypochlorite for 120 minutes in order to remove organic material and achieve microbial control. Immediately after that, they were washed in running water for 1 hour and stored in a solution containing 50% water and 50% glycerin to rehydrate for 48 hours.

Afterwards, the teeth were measured with the aid of a ruler, so as to standardize their size: 15 mm in length in the apex-crown direction. The teeth were then mounted on an acrylic tray, attached to a plastic vise, with subdivisions that allow irrigation instruments, material and liquids to be placed in. This tray was developed by Braitt.⁸ The working length was determined by placing a #15 Flexofile instrument until its tip was visualized in the foramen, subtracting 1 mm. In other words, the working length was set at 14 mm. Shaping was carried out by means of the ProTaper Universal (Dentsply / Maillefer) system, using the technique advocated by Pierre Matchou. SX instruments were used up to 2/3 of the working length, followed by F3, F4 and F5 instruments up to the working length and driven by the rotary device Endo Plus (VK DRILLER Electric Equipment Ltd - São Paulo - Brazil) at a speed of 300 rpm and torque of 3N/cm². New files were used for every three teeth, so as to prevent instrument wear from negatively affecting root canals cleaning. The irrigating solution used was 5.0 ml of 2.5% sodium hypochlorite (Bleach Brilux, São Paulo, Brazil) applied at each change of instruments during shaping.

Root canals were then dried by aspiration, filled with 17% EDTA (Pharmapele, Itabuna, Brazil) kept for three minutes, followed by agitation with lentulo bur for one minute to remove the smear layer, and final irrigation with 5.0 ml of sodium hypochlorite. Once instrumentation was completed, the teeth were irrigated with 1 ml of isopropyl alcohol and dried with ProTaper F3 paper cone.

After drying the canals by aspiration and with absorbent paper points, the filling procedure was carried out by means of the thermoplasticized gutta-percha technique, advocated by John MacSpadden and modified at the Center for Endodontic Research.⁸ It consists in inserting a ProTaper F5 cone, the last instrument to reach the working length, into each tooth. This cone is then adapted to the root canal and marked by a cotton tweezer, so as to function as reference to the working length. Subsequently, the cone is removed and the canal filled with EndoFill sealer with the aid of a lentulo bur. The cone is reinserted and thermoplasticized with a

gutta-percha #80 condenser penetrating the root canal at a speed of 13,000 rpm, clockwise, without surpassing the mid third (the instrument diameter does not allow gutta-percha to flow through the apical foramen), until plastification is achieved. The cone is removed from the root canal at 13,000 rpm.

In specimens in which filling was insufficient, a heated spacer was inserted to create space where another accessory FM gutta-percha cone (Odous De Deus, Belo Horizonte, MG, Brazil) was introduced. The thermo-plastification procedure was then repeated and, as a result, better root canal obliteration was achieved. Excess gutta-percha was removed and vertical condensation carried out with a Schilder #4 condenser. Double sealing was performed with coltosol and glass ionomer after the coronal portion was removed, under refrigeration, with the aid of carbon discs.

Once instrumentation and filling procedures were completed, the specimens were randomly divided into four groups: two experimental and two control (Table 1).

Groups 1, 2 and 3 were subjected to apicoectomy and retropreparation with an ultrasonic tip. Group 4 did not undergo either apicoectomy nor retropreparation, thereby serving as positive control. Group 1 was retrofilled with MTA-water, mixed according to the manufacturer's instructions (1 g of powder for every drop of distilled water). Group 2 was retrofilled with 1 g of MTA (Angelus, Londrina, Brazil) for every 2 ml of Fillapex sealer. Group 3 was not retrofilled and served as negative control.

The roots of Group 4 received two coats of red nail polish (Risqué - Niasi, Taboão da Serra, Brazil) at their entire length; whereas the roots of Groups 1, 2 and 3 were also coated, except in the region where apicoectomy

was carried out. A 24-hour period was rendered necessary for complete drying at room temperature.

Apicoectomy was carried out by means of a Zekrya KG 199Z drill (Dentsply Maillefer, Ballagues, Switzerland) at high speed and under spray with water. Sections were performed in 90°, throughout the root axis, 3 mm from the root apex.

Retrograde cavities were prepared approximately 3 mm deep with the aid of a F1290 ultrasonic tip (Gnatus, Ribeirão Preto, Brazil) coupled to an ultrasound device (Gnatus).

Subsequently, once the coating and drying procedures were completed, the roots were distributed into test tubes made of standard glass and which were properly identified and placed at a specific support for storage.

In order to allow roots to be easily handled, they were attached to a metal rod by means of heated gutta-percha, removed from a dental suction unit with the aid of a needle holder and coupled to the lid of the test tube.

Afterwards, the retrofilling procedure with Groups 1 and 2 began. The material, MTA-water and MTA-Fillapex, was inserted into the respective cavities of Groups 1 and 2, with the aid of a MTA carrier (Angelus, Londrina, Brazil), and accommodated with Schilder #4 condenser (De Deus, Odous Industry and Trade, Belo Horizonte, Brazil). Excess was removed with a spatula #1.

Each group of specimens was then immersed in 3 ml of 1% rhodamine B, in test tubes made of standard glass, identified and placed in a microbiological culture incubator, at 37 °C and 100% humidity for eight days. After this period, the roots were removed from the dye solution and had the external coating removed by a Le Cron spatula. The roots were washed in running water for five minutes and let dry at room temperature for 24 hours, so as to allow dye fixation. Subsequently, they were immersed in running water for 12 hours and left to air-dry for 12 hours.

Specimens were sectioned longitudinally with a steel disk, cleaved with a Le Cron spatula and photographed at the same lens-object distance. The photographs were sent to three specialists in Endodontics who filled in a table to assess the following levels of leakage: zero; 0-1 mm; 1-2 mm and 2-3 mm, without knowing to which group each tooth belonged. All three tables were sent for statistical analysis.

Once reliability was assessed, a study was conducted to compare the amount of leakage, with a view to giving support to the existence, or not, of significant differences

Table 1. Distribution of specimens and identification of groups.

Groups	Tested associations	Number of specimens
1	MTA-water	20
2	MTA-Fillapex	20
Positive control	-	5
Negative control	-	5
Total		50

between the different types of material assessed. To this end, the mixed-effects analysis of variance model was used and adapted to compare the mean values of dye leakage in the different groups (MTA-water and MTA-Fillapex).

Results

Results are shown in Figures 1 and 2. Figure 1 corroborates the high recurrence of teeth without leakage for teeth included in the different categories associated with a certain degree of leakage, and some similarity among the results yielded by the three evaluators. Figure 2 corroborates higher degrees of leakage in the MTA-water group compared to the MTA-Fillapex group. The mean leakage value for the MTA-water group is significantly greater (0.65) than the MTA-Fillapex group (0.34).

Results not only reveal that evaluators were consistent, but also that the MTA-Fillapex group had less leakage of dye than the MTA-water group.

In the positive control group, specimens did not have dye leakage in the retrograde cavity, whereas specimens from the negative control group had the retrograde cavity completely infiltrated.

Chi-square test applied to all evaluators reveals that analysis of results begins with strong evidence ($p < 0.01$) of difference between the degrees of leakage.

All evaluators more frequently assessed teeth without leakage. Evaluator 1 found 23 teeth without leakage, which accounted for 57.50% of the sample. On the other

hand, evaluator 2 found 20 teeth (50.00%) without leakage; whereas evaluator 3 found 22 teeth (55.00%) also without leakage.

The relatively similar percentage of teeth without leakage helped us understand not only that there is relative compliance among evaluators, but also that leakage is not a recurring event, as it occurs in half, or less than half, of teeth.

Reliability results from a consensus established among the three evaluators, with regard to the degree of leakage, when assessing the same tooth. In this context, statistical analysis arises, beginning with agreement values, calculated on the basis of the number of times two evaluators attributed the same degree of leakages for a given tooth.

Evaluators 1 and 2 agreed in 22 of 40 samples; that is, they assigned the same degree of leakage in 55.00% of cases. Evaluator 3 showed much more satisfactory agreement with evaluator 1 (30 cases or 75.00%) and evaluator 2 (29 cases or 72.50%).

There was strong discrepancy when one evaluator pointed out leakage ranging from 2 to 3 mm while another evaluator claimed having found no leakage at all. Nevertheless, this was an isolated fact and occurred when evaluator 3 found leakage ranging from 2 to 3 mm while evaluator 1 found no leakage in sample 35.

Thus, assessment of reliability neither lead us to conclude that evaluators differ in terms of criteria nor that there are no problems involved in the quantifying process and which cannot be attributed to chance.

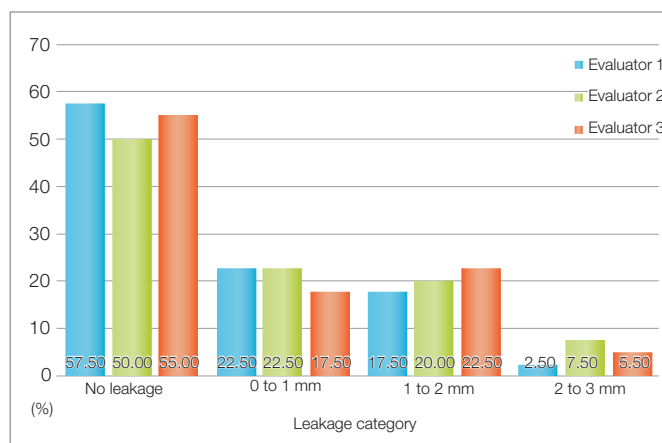


Figure 1. Percentage of teeth indicated by the evaluators in different depth-of-leakage categories.

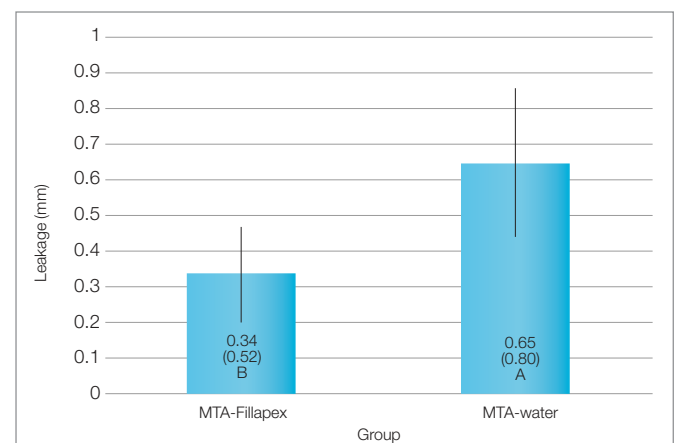


Figure 2. Mean, standard deviation and leakage mean limit of confidence interval (95%) of groups.

*The same letters indicate true means that do not differ by Tukey test with a significance level set 5%.

The next step was to perform analysis of variance to compare the mean value of each quality criterion observed, depending on the groups characterized by the application of different products.

Analysis of variance is a process based on the adaptation of a mathematical model that allows effects to be quantified and tested. In order to carry out the analysis of variance, rather than degrees of leakage, there is a need to work with numerical values. For this reason, when there was no leakage, we adopted a value equal to 0; leakages ranging from 0 to 1 mm (class 1) were associated with a value equal to 0.5 mm; leakages ranging from 1 to 2 mm were associated with a value equal to 1.5 mm; and, finally, leakages ranging from 2 and 3 mm were associated with a value of 2.5 mm.

Additionally, two data had to be excluded. Two values equal to 2.5 (one recorded by evaluator 2 in sample 31, and the other recorded by evaluator 3 in sample 35) proved harmful to the analysis.

Discussion

Samples were standardized in 15 mm in order to minimize differences between the canals. Arnditis, Bryant and Blackler⁹ claim that lack of standardization of samples when measuring microleakage is a significant factor, mainly imposed by the impossibility of anatomical standardization, since dental anatomy is extremely diverse.

Gilheany, Figdor e Tyas¹⁰ highlight that, during apicoectomy, both the height and inclination of the cut should be carefully performed due to exposure of dentinal tubules and accessory canals. The procedure should be performed at once and include the entire buccolingual extension of the root. Araújo et al¹¹ report that the height of apicoectomy should be around 3 mm, varying according to anatomical changes of the root canal. Additionally, the authors claim that the ideal is that the cut be horizontally made so as to eliminate potentially isthmuses-contaminated areas, apical deltas, accessory and secondary canals, in addition to reducing the potential for marginal leakage. The aforementioned recommendations were followed in the present research.

Since the area of interest was the apical surface of the root, in order to investigate the degree of leakage occurring between the retrofilling material and the dentinal wall, the entire outer surface of the root was coated with two layers of nail polish, with a six-hour interval for drying.¹²

With a view to reproducing a clinical situation close to reality, the method of immediate immersion of retrofilled units into the dye, without investigating the sealer setting time, was employed. The tubes containing the samples immersed in rhodamine B were placed in a microbiological culture incubator and kept there for at least 8 hours, at 37 °C and 100% humidity, so as to simulate the temperature and humidity of the human body. This method was used by Helleno et al¹³ to assess the ability of 2% methylene blue dye, 2% rhodamine B and 5% nickel sulfate in marking crown microleakage. The authors also coated the samples with nail polish.

Similarly to Vaz,¹⁴ after removing the dye, specimens were washed in running water for 5 minutes and dried at room temperature for 24 hours, so as to allow dye fixation.

According to Torabinejad et al,¹⁵ when a given filling material does not allow leakage of small molecules, such as dye particles, it has the potential to prevent bacterial leakage, as bacteria have a larger molecular size. Therefore, the low degree of dye microleakage allowed by Groups 1 (MTA-water) and 2 (MTA-Fillapex) can point out to a great potential for bacterial seal, as proven by Nataka, Bae and Baumgartner¹⁶ and Torabinejad et al.¹⁷ These authors assessed the sealing ability of MTA and other types of repair material by means of bacteria leakage tests, and found that MTA allowed less leakage.

According to Taylor and Lynch,¹⁸ several methods are used to assess microleakage: use of bacteria, compressed air, chemical and radioactive markers, electrochemical studies, scanning electron microscopy and dye penetration tests. Dejou, Sindres and Camps¹⁹ reported that a wide variety of methods have been described to assess the sealing capacity of a given material; however, dye penetration tests are undoubtedly the most widely used and described in the literature, generally due to being simple and fast.

One disadvantage, according to Delivanis and Chapman,²⁰ is that dyes do not allow continuous measurement of leakage in the same specimen, since they allow measuring the degree of leakage up to the moment when the teeth are removed from the solution, only. However, according to Taylor and Linch,¹⁸ this is a highly sensitive technique that requires standardization.

Furthermore, these authors claim that the dyes commonly used in research with teeth are provided in the form of solution or suspension with different particles sizes, depending on the manufacturer and the particular

behavior of each dye, and, therefore, it is impossible to continue using a variety of dyes with the expectation of achieving consistent results, even when a standard technique is employed. Another potential cause of error is the ability of a dye to bind to the dental substance or restorative material. In addition, the dyes should also have color stability under any circumstances faced during research.

Although several studies have been conducted to find the best marking solution used to assess marginal microleakage, the relevant results found in the literature are discrepant, since various dyes were used at different immersion times. For this reason, Brandão²¹ reported the nonexistence of standards or norms for this type of test, and, therefore, the wide variability among tests. Perhaps that is the reason why the use of dye solutions as leakage markers has been questioned in recent years. In addition, the author assessed the reliability of apical leakage tests carried out with 0.5% methylene blue, 0.2% rhodamine B and fluid transport system in root canal filling after the use of calcium hydroxide dressing. He concluded that calcium hydroxide established a chemical interaction with methylene blue, since only the results yielded by the use of methylene blue showed statistically significant difference between groups with and without dressing.

Dye leakage methods are questionable because they are not fully reproducible and are not subjected to standardization norms. There are numerous variables, such as the immersion period of the specimen into the marker, which may be direct (before sealer setting) or indirect; the time of immersion; the use or nonuse of negative pressure (vacuum) to remove air trapped within filling gaps; total or partial immersion of the specimen into the dye; type of seal; number of specimens; volume of the marker; position of specimens during immersion; and especially the type of marker used.⁷

Furthermore, Starkey, Anderson and Pashley²² emphasized that the pH of the dye solution is another potential variable. Therefore, it seems reasonable to use dye solutions with a neutral pH, as in the present study, so as to avoid variables inherent to the methods, that is, technical artifacts.

The depth of penetration of dyes into the tooth structure varies according to the amount of air trapped within the canal.²³ In the present study, vacuum was not used and dye penetration occurred passively; a situation that resembles clinical reality. Air removal may lead to overestimation of the extent of microleakage *in vivo*.²⁴

On the other hand, Noguera and McDonald²⁵ demonstrated that the use of vacuum allows a more accurate assessment of dye penetration to be carried out due to the space between the sealing material and the canal walls.

In the method employed in this study, we chose to use rhodamine B due to having smaller and more surface-active molecules than methylene blue, in addition to not undergoing changes in the presence of substances rich in calcium. Perhaps this explains the greater penetration rates achieved and the best visualization of rhodamine B dye in other studies.^{12,26,27}

For a given retrofilling material to be correctly recommended, its biological properties should be studied. In this sense, mineral trioxide aggregate has received particular attention due to having good biological properties.^{28,29} The present study aimed at using clinically relevant methods, with a view to reproducing or resembling the oral cavity. For this reason, specimens were immersed in rhodamine B dye solution soon after inserting the material tested herein in both groups and in the retrograde cavities.

The use of methylene blue dye in leakage researches has been questioned,^{30,31} since the solution undergoes a bleaching process in the presence of alkaline substances, which influences the results. Thus, in order to assess the sealing ability of MTA, the use of dye solutions, which do not negatively affect the alkalinity of their marking capability, as rhodamine B solution, is recommended, as used in the present study.

MTA has calcium oxide in its composition. When mixed with water, this compound produces calcium hydroxide and causes the pH to increase, as shown by Duarte et al,³² who assessed two different types of MTA-based material. This shows that there might be discoloration of surfaces marked by methylene blue.³³ Thus, to assess the sealing ability of MTA, it is recommended to use other markers, such as rhodamine B solution, as used in this study.

The difference between Pro Root MTA and MTA Angelus is the absence of 5% of calcium sulfate in the latter. The function of calcium sulfate is to prevent rapid dehydration of the mixture after spatulation.^{34,35} Additionally, MTA Angelus has a larger amount of calcium carbonate, calcium silicate and barium zinc phosphate in its composition, when compared to conventional MTA, which contributes to improve time, work and ability setups.³⁶

The present study tried to reproduce a clinical situation that resembles reality, and, for this reason, opted for immediate immersion of retrofilled specimens into dye, without observing the sealer setting time. This might explain the discrepant results when this study was compared to similar ones.

Araújo et al¹¹ reported that periapical surgery success does not rely on correct procedures and indication only, but also, in cases in need of retrograde filling, on the use of biocompatible marginal retrograde material, which promotes good apical seal, thereby preventing the penetration of periapical fluids into the root canal system. In the present research, it is clear that the combination of MTA and Fillapex sealer promoted better apical seal than MTA alone, manipulated according to the manufacturer's instructions.

One of the main factors responsible for endodontic treatment failure is microleakage,^{3,37,38,39} with the majority of cases of failure involving surgical treatment with retrofilling being associated with the sealing ability of the material used for this purpose.

According to Barbosa,³⁹ paraendodontic surgery is an option for cases of retreatment failure or contraindication. Estrela et al⁴⁰ report that endodontic retreatment should be the first therapy of choice in cases of failure, as it usually yields successful results. However, some cases of retreatment might pose a serious risk in the event of keeping the tooth.

Gutmann and Harrison⁴¹ report that the purpose of retrofilling is to achieve apical seal of a prepared root. In this context, the ideal retrofilling material should be biocompatible with periapical tissues, nonresorbable, impermeable to dissolution or desegregation by tissue fluids, and capable to adapt to the dentin walls of retrograde cavities. Given that surgical therapy success relies on proper apical seal, MTA is undoubtedly the best option due to achieving the best marginal seal, being compatible and inducing osteogenesis and cementogenesis.

Several researches corroborate the aforementioned data. Holland et al⁴² and Gomes Filho et al⁴³ report that MTA promotes favorable tissue responses characterized by absence of severe inflammatory response, presence of fibrous capsule and induction of mineralized tissue repair.

According to the results yielded in the present study as well as in the study conducted by Torabinejad et al,^{17,28} MTA has excellent biocompatibility to tissues and provides hermetic seal. Along with satisfactory radiopacity, these

are also included in the set of characteristics required by an ideal repairing material. Despite not having good antimicrobial activity,⁴⁴ its high pH is incompatible with most microorganisms, which inhibits bacterial enzymes.^{45,46}

In spite of the above, difficulty inserting the material into retrograde cavities might be considered relevant, because if the material is not properly inserted into the cavity, its good sealing property will be compromised. Conversely, the hydrophilic property of the material is a great advantage, since, most of times, especially during apical surgery, there is considerable difficulty in maintaining a dry environment. In addition, because MTA starts to harden when it reacts with water, the humidity present in the tissues acts as an activator of the compound chemical reaction,⁴⁷ which extends its setting time to 2 hours and 45 minutes.⁶

In order to justify the lowest leakage allowed by MTA mixed with Fillapex, it is reasonable to assume that such an association speeds the sealer setting time up. On the other hand, this does not justify the greater leakage observed in the MTA-water group, particularly due to the expansion the material was subjected to as a result of the presence of double-hydrated 5% calcium sulfate, which expands during the setting time and may, therefore, contribute to better marginal adaptation.⁴⁸

Torabinejad et al⁶ reported that the sealer resulting from mixing MTA powder and water is difficult to handle. Lee⁴⁷ also reported that, due to the slow setting time of MTA after the mixing procedure, it becomes a retrofilling material difficult to handle. For this reason, the present study opted to use a MTA-based sealer (Fillapex) that renders MPA handling easier after spatulation. Nevertheless, according to Moraes et al,³¹ the difference between Pro Root MTA and MTA Angelus (used in this study) is the absence of 5% calcium sulfate in the composition of MTA Angelus. The function of this compound is to prevent rapid dehydration of the mixture after spatulation.

In agreement with results yielded by previous studies,^{8,49} MTA Angelus achieves significant sealing rates. However, the literature comprises a limited number of reports on the use of Fillapex.⁵⁰ Associating it with MTA, instead of what is recommended by the manufacturer, renders the process of handling it easier, in addition to enhancing its adaptation into the retrograde cavity. Despite these results, no similar reports are found in the literature, which reveals the need for further research.

Fillapex is a MTA-based endodontic sealer with high consistency and resin compounds. Its manufacturer

claims it to have excellent radiopacity and long working time, in addition to being easily handled. Nevertheless, there is lack of scientific evidence on this matter.

The results yielded by this study with Group 1 (MTA-water) confirm those achieved by Lee et al⁵¹ who used methylene blue for 48 hours; Torabinejad et al⁴ who used fluorescent rhodamine B for 24 hours; Fogel and Peikoff⁵² who used the fluid filtration system; and Tang, Torabinejad and Kettering³⁶ who used the endotoxin leakage system; all of which showed less apical microleakage with the use of MTA compared to other types of material tested.

The present study associated water with MTA according to Torabinejad et al.⁶ who reported that MTA proves efficient in promoting apical seal, thereby preventing leakage of dyes and bacteria. Tanomaru Filho et al⁵³ also reported satisfactory sealing with Sealer 26, Pro Root MTA and MTA Angelus compared to zinc oxide and Eugenol.

However, Group 2 (MTA-Fillapex) could not be compared to previous studies due to lack of research with similar associations. In spite of that, results are promising and better than Group 2. Thus, based on the results achieved herein, it is reasonable to state that the association of MTA with Fillapex sealer was more efficient in preventing microleakage of rhodamine B dye than MTA mixed with water.

In Group 2, the association of MTA with Fillapex sealer aimed at rendering the manipulation of the material easier, but without affecting their promising properties. Holland et al²⁹ used MTA in root canal filling systems and proved that MTA combined with propylene glycol paste is easily inserted into the root canal of canines.

Moraes et al⁵⁴ reported that methylene blue in contact with alkaline material undergoes discoloration, losing its marking power, which cast doubt on the low levels of

leakage observed in their study when using MTA. Tanomaru Filho et al⁵⁵ assessed the apical sealing ability of different types of retrofilling material by means of rhodamine B. Their results revealed that the group retrofilled with Sealer 26 had the lowest marginal leakage and ZOE and MTA Angelus were similar in terms of sealing ability.

In this study, the assessment of apical leakage carried out by means of rhodamine B dye reveals that the association between MTA and Fillapex was beneficial and preserved the material properties of apical seal.

Analysis of variance, basic statistics and Tukey test reveal that the sealing ability resulting from the association between MTA and Fillapex was greater than that of the MTA-water association.

No technique or material is able to cover all physicochemical and biological characteristics necessary to achieve the ideal repair and allow the material to be easily handled. Such demand motivates new researches to be carried out with existing material, manipulated according to the manufacturer's instructions and associated with others, or the development of new material. Scientific evidence is not grounded on hypothesis; rather, it aims at achieving understanding through suitable research conducted before using a given material in human beings.

The lack of research on the association between MTA and Fillapex warrants further studies, seeking ground on scientific evidence.

Conclusion

Under the experimental conditions of this study, using rhodamine B dye solution and based on the results yielded herein, it is reasonable to conclude that MTA sealer associated with Fillapex presented greater sealing ability when compared to MTA mixed according to the manufacturer's instructions.

References

- Sayago MEM, Pinto PLM, Collesi JPP. Cirurgia perirradicular. In: Lopes HP, Siqueira Jr JF. Endodontia: biologia e técnica. São Paulo: Medsi; 1999. p. 577-97.
- Leonardo MR. Tratamento de canais radiculares: princípios técnicos e biológicos. 4ª ed. São Paulo: Artes Médicas; 2008. v. 2.
- Tanomaru Filho M, Jorge EG, Barbizam JVB, Tanomaru JMG. Avaliação da capacidade seladora apical de materiais retro obturadores à base de mineral trióxido agregado (MTA) e de óxido de zinco e eugenol, em corante rodamina B. Rev Faculdade Odontol Passo Fundo. 2005;10(2):59-62.
- Torabinejad M, Watson TF, Pitt Ford TR. Sealing ability of a mineral trioxide aggregate when used as a root end filling material. J Endod. 1993;19(12):591-5.
- Torabinejad M, Hong CU, Pitt Ford TR, Kettering JD. Antibacterial effects of some root-end filling materials. J Endod. 1995;21:403-6.
- Torabinejad M, Rastegar AF, Kettering JD, Pitt Ford TR. Bacterial leakage of mineral trioxide aggregate as a root-end filling material. J Endod. 1995;21:109-12.
- Wu MK, Wesselink PR. Endodontic leakage studies reconsidered. Part I. Methodology, application and relevance. J Endod J. 1993;1:37-43.
- Braitt GR. Avaliação in vitro da micro infiltração em três materiais utilizados em retro obturação [Trabalho de Conclusão de Curso]. Salvador (BA): Faculdade de Tecnologia e Ciências; 2007.
- Amditis C, Bryant RW, Blackler SM. The assessment of apical leakage of root-filled teeth by the electrochemical technique. Aust Dent J. 1993;38(1):22-7.
- Gilheany PA, Figdor D, Tyas MJ. Apical dentin permeability and microleakage associated with root end resection and retrograde filling. J Endod. 1994;20:22-6.
- Araújo RA, Delboni MG, Bueno CE, Miguita KB, Cunha RS. Avaliação do selamento apical após retro-obturações com a utilização de duas diferentes marcas de MTA. J Bras Endod. 2004;5(17):150-6.
- Gonçalves SB, Bramante CM. Avaliação in vitro da capacidade seladora do Super-EBA e MTA em quatro técnicas de obturação retrógrada. Rev Facul Odontol Bauru. 2002;10(3):170-8.
- Helleno JFG, Nunes E, Côrtes MIS, Silveira FF. Avaliação da capacidade de marcação de microinfiltração coronária de três corantes. Dental Press Endod. 2012;2(2):30-6.
- Vaz RR. Avaliação de alguns materiais impermeabilizantes utilizados na verificação da infiltração marginal. Arq Cent Estud. 1992;29:41-5.
- Torabinejad M, Riga RK, McKendry DJ, Ford TRP. Dye leakage of four root end filling materials: effects of blood contamination. J Endod. 1994;20(4):159-63.
- Nataka TT, Bae KS, Baumgartner JC. Perforation repair comparing mineral trioxide aggregate and amalgam using an anaerobic bacterial leakage model. J Endod. 1998;24(3):184-6.
- Torabinejad M, Hong CU, Lee SJ, Monsef M, Pitt Ford TR. Investigation of mineral trioxide aggregate for root-end filling in dogs. J Endod. 1995;21(12):603-8.
- Taylor MJ, Lynch E. Microleakage. J Dent. 1992;20(1):3-10.
- Dejou J, Sindres V, Camps J. Influence of criteria on the results of in vitro evaluation of microleakage. Dent Mater. 1996;12(6):342-9.
- Delivanis PD, Chapman KA. Comparison and reliability of techniques for measuring leakage and marginal penetration. Oral Surg Oral Med Oral Pathol. 1982;53(4):410-6.
- Brandão CG. Confiabilidade dos testes de infiltração apical com azul de metileno, rodamina B e sistema de transporte de fluidos em obturações de canais após uso de curativo de hidróxido de cálcio [tese]. Bauru (SP): Universidade de São Paulo; 2005.
- Starkey DL, Anderson RW, Pashley DH. An evaluation of the effects of methylene blue dye pH on apical leakage. J Endod. 1993;19(9):435-9.
- Spangberg LSW, Acierno TG, Cha BY. Influence of entrapped air on the accuracy of leakage studies using dye penetration methods. J Endod. 1989;15:548-51.
- Beckham BM, Anderson RW, Morris CF. An evaluation of three materials as barriers to coronal microleakage in endodontically treated teeth. J Endod. 1993;19:388-91.
- Noguera AP, McDonald NJ. A comparative in vitro coronal study of new endodontic restorative materials. J Endod. 1990;16:523-7.
- Sousa MC, Bernardineli N, Brebert A. Infiltração de corantes em obturações de canais radiculares em função de cimentos e tempos de imersão. Rev Facul Odontol. 1994;2:23-8.
- Hamaoka L, Moura AA. Avaliação in vitro da permeabilidade dentinária radicular, tendo como fonte de variação três diferentes tipos de corantes. Rev Odontol Univ São Paulo. 1996;10(1):39-42.
- Torabinejad M, Pitt Ford TR, McKendry DJ, Abedi HR, Miller DA, Kariyawasam SP. Histologic assessment of mineral trioxide aggregate as a root-end filling in monkeys. J Endod. 1997;23:225-8.
- Holland R, Mazuqueli L, Souza V, Murata SS, Dezan Júnior E, Suzuki P. Influence of the type of vehicle and limit of obturation on apical and periapical tissue response in dogs' teeth after root canal filling with mineral trioxide aggregate. J Endod. 2007;33:693-7.
- Wu MK, Kontakiotis EG, Wesselink PR. Decoloration of 1% methylene blue solution in contact with dental filling materials. J Dent. 1998;26(7):585-9.
- Moraes FG, Duarte MAH, Moraes IG. Influência do condicionamento dentinário final e do material retro-obturador no selamento de obturações retrógradas. J Bras Endod. 2005;21-22:476-82.
- Duarte MAH, Demarchi ACCO, Yamashita JC, Kuga MC, Fraga SC. pH and calcium ion release of 2 root-end filling materials. Oral Surg Oral Med Oral Pathol. 2003;95(3):345.
- Silva Neto UX, Brochado VHD, Gonçalves Jr JF, Westphalen VPD, Moraes IG. Infiltração marginal em obturações retrógradas realizadas com Pro Root MTA, MTA-Angelu e Super EBA. J Bras Endod. 2003;4(13):149-52.
- Estrela C. Cirurgia parestodôntica: como praticá-la com embasamento científico. In: Estrela C. Ciência Endodôntica. 2ª ed. São Paulo: Artes Médicas; 2004. v. 2.
- Parirokm M, Torabinejad M. Mineral trioxide aggregate: a comprehensive literature review – Part I: chemical, physical, and antibacterial properties. J Endod. 2010;36:16-27.
- Tang HM, Torabinejad M, Kettering JD. Leakage evaluation of root end filling materials using endotoxin. J Endod. 2002;28(1):5-7.

37. Matt GD, Thorpe JR, Strother JM, McClanahan SB. Comparative study of white and gray mineral trioxide aggregate (MTA) simulating a one-ortwo-step apical barrier technique. Study of White and Gray MTA. *J Endod.* 2004;30(12):876-9.
38. Bernabé PFE, Holland R, Morandi R, Souza V, Nery MJ, Otoboni Filho JA, et al. Comparative study of MTA and other materials in retrofilling of pulpless dogs'teeth. *Bras Dental J.* 2005;16(2):149-55.
39. Barbosa SV. *Terapêutica endodôntica.* São Paulo: Ed. Santos; 1999.
40. Estrela C, Camapum FF, Lopes, HP. Insucessos em endodontia. In: Estrela C, Figueiredo JAP. *Endodontia: princípios biológicos e mecânicos.* São Paulo: Artes Médicas; 1999. cap.19. p. 697-738.
41. Gutman JL, Harrison JW. *Surgical endodontics.* St. Louis: Ishiyaku Euro America; 1994.
42. Holland R, Otoboni Filho JA, Souza V, Nery MJ, Bernabé PF, Dezan Júnior E. Mineral trioxide aggregate repair of lateral root perforations. *J Endod.* 2001;27(4):281-4.
43. Gomes Filho JE, Watanabe S, Bernabé PF, Moraes Costa MT. A mineral trioxide aggregate sealer stimulated mineralization. *J Endod.* 2009;35:256-60.
44. Estrela C, Bammann LL, Rodrigues C, Silva RS, Pécora JD. Antimicrobial and chemical study of MTA, portland cement, calcium hydroxide paste, sealapex and dycal. *Braz Dent J.* 2000;11(1):3-9.
45. Estrela C, Sydney GB, Bammann LL, Felipe Jr O. Estudo do efeito biológico do pH na atividade enzimtica de bactérias anaeróbias. *Rev Facul Odontol Bauru.* 1994;2(4):31-8.
46. Estrela C, Sydney GB, Bammann LL, Felipe Jr O. Mechanism of action of calcium and hydroxylions of calcium hidroxide on tissue and bactéria. *Braz Dent J.* 1995;6(2):85-90.
47. Lee ES. A new Mineral Trioxide Aggregate root-end filling technique. *J Endod.* 2000;26(12):764-5.
48. Peters CI, Peters OA. Occlusal loading of EBA and MTA root-end fillings in a computer-controlled masticator: a Scanning Electron Microscopic study. *Int Endod J.* 2002;35(1):22-9.
49. Andelin WE, Browning DF, Hsu GR, Roland DD, Torabinejad M. Microleakage of resected MTA. *J Endod.* 2002;28(8):573-4.
50. Borges RP, Souza-Neto MD, Versiani MA, Rached Jr FA, De Deus G, Miranda CES, et al. Changes in the surface of four calcium silicate-containing endodontic materials and an epoxy resin-based sealer after a solubility test. *Int Endod J.* 2011;45(5):419-28.
51. Lee SJ, Monsef M, Torabinejad M. Sealing ability of a mineral trioxide aggregate for repair of lateral root perforations. *J Endod.* 1993;19:541-4.
52. Fogel H, Peikoff M. Microleakage of root-end filling materials. *J Endod.* 2001;27(7):456-8.
53. Tanomaru JMG, Ashikawa TM. Capacidade de selamento apical de materiais retrobturadores à base de agregado de trióxido mineral. *J Bras End.* 2003;4(12):20-3.
54. Moraes IG, Nunes E, Berbert A, Duarte MAH, Betti LV. Influência do hidróxido de cálcio e do EDTA na marcação da infiltração marginal de azul de metileno em obturação de canais radiculares. *Rev Facul Odontol Bauru.* 2000;1-2:37-44.
55. Tanomaru M, Jorge EG, Tanomaru JMG. Avaliação da capacidade seladora apical de materiais retrobturadores empregando corante rodamina B. *J Bras Endod.* 2006;6(24):89-93.