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ORIGINAL RESEARCH

Comparative Analysis of the pH Levels and the Amounts of Calcium Ions Emitted by the Most Recent Calcium Silicate-Based Root Canal Sealers

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Abstract
Introduction: The purpose of root canal therapy is to obturate the root canal system in a three-dimensional manner so as to prevent the introduction of germs and fluid into the root canal system. Recent Calcium Silicate Sealers (CSS) are said to be great sealers because they have an alkaline pH, low solubility, and provide effective sealing as a result of their setting expansion. Additionally, it has been suggested that they are excellent sealers. There are not nearly enough papers that demonstrate their physiochemical behavior at this point in time.
Objective: The objective of this study is to assess and compare the pH as well as the calcium ion release in more modern root canal sealers that are based on calcium silicate.
Materials and the Methods: We compared three calcium silicate sealers that are commonly used. These calcium silicate sealers were categorized as follows: Group 1 (n = 10) served as a control group; Group 2 (n = 10) consisted of sealapex; Group 3 (n = 10) consisted of mineral trioxide aggregate (MTA) fillapex; and Group 4 (n = 10) consisted of White MTA. After preparing the polyethylene tubes and dividing the contents into the appropriate groups, the tubes were filled. After the tubes were filled and the flask was sealed, it was kept at a temperature of 37 degrees Celsius for the entirety of the assessment period at various intervals of twenty-four hours, seven days, and one month. Both the pH and the amount of calcium ion that was released were determined using an atomic absorption spectrophotometer and a pH meter, respectively.
Results: After 24 hours, the results indicated that White MTA had the highest pH as well as the largest calcium (Ca++) release. Even after one month of the research, the ph of MTA fillapex remained alkaline. Even after 30 days, MTA Fillapex exhibited the greatest Ca++ release, which steadily grew as well as continued to climb.
Conclusion: Greater solubility of MTA Fillapex with time as compared to the other two materials provides an explanation for the conclusion that MTA Fillapex demonstrates stronger alkalinizing ability and Ca++ release of as compared to White MTA and (Sealapex) with increase in time intervals.

Introduction
The purpose of root canal therapy is to generate a three-dimensional obturation of the root canal system in order to prevent germs and fluid from entering the canals of the affected tooth.1,2 Hermetic sealing requires the use of core materials like gutta-percha (GP) and root

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canal sealers. These are necessary components.3,4 The application of endodontic sealers that have therapeutic characteristics has provided the potential for a greater success rate in root canal therapy, as has the introduction of these sealers.

Root canal sealers contain characteristics that can influence their clinical, biological, and antibacterial activities, such as changes in pH and the components that are released. After root canal obturation, an alkaline pH is strongly associated to an increased release of hydroxyl and calcium ions (Ca2+). This release prevents the growth of any bacteria that may have been left behind, which in turn speeds up the healing process of periapical pathosis. 5,6

Rohner was the one who initially reported using calcium hydroxide in a therapeutic setting in the root canal in the year 1940. As a result, researchers began concentrating their efforts on calcium (Ca++) based sealers because of the antibacterial activity that these sealers possess as a result of the Ca++ releasing potential of calcium. The fact that these sealers have the capability of producing a highly alkaline atmosphere has contributed to their widespread adoption.

Dr.Torabinejad came up with the idea for MTA in 1993 when he was working at Loma Linda University. MTA is a complicated mixture that consists of hydrophilic tricalcium silicate, tricalcium oxide, and tricalcium aluminate, all of which have oxides added to them (bismuth oxide). 8 Because MTA has been proven in a number of studies to be biocompatible, to have the ability to accelerate mineralization, and to have the capability of depositing crystals in dentin that are similar to apatite, its use as a sealer has been recommended as a result of these findings. On the other hand, it has revealed several distinct shortcomings, such as a lengthy setting time and difficult handling features. 10 Numerous novel materials based on calcium silicate have been developed in order to mitigate some of the problems associated with MTA. 11

The MTA Fillapex sealer is the most recent of these products. That essentially consists of MTA combined with salicylate resin, natural resin, bismuth, and silica. Because of the ease with which they may be handled, they are ideally suited for use as a sealer in canals. On the other hand, not a lot of study has been done on the physiochemical and biological aspects of MTA Fillapex. It has been said that the 12 most recent calcium silicate sealers (CSS) are excellent sealers due to their alkaline pH, limited solubility, and the fact that they provide superior sealing as a result of their setting expansion. There are not nearly enough papers that demonstrate their physiochemical behavior at this point in time. Therefore, it is essential to determine the pH of these materials as well as the amount of Ca++ that they release in order to evaluate their capacity for alkalinization and the mineralization that they induce.

Because of this, the purpose of this study was to examine the pH and calcium ion release of a novel calcium silicate-based sealer called MTA Fillapex and compare it to White MTA and the traditional calcium hydroxide-based sealer called sealapex.

Materials and methods

In this particular research endeavor, the root canal sealers that were evaluated were Sealapex, MTA Fillapex, and White MTA. A bard parker blade and a digital Vernier caliper were used to cut N" polyethylene tubing into 35 tubes of identical length and diameter. Each tube measured 10 millimeters in length and had a diameter of 1.0 millimeter. In order to prevent interference with phosphate ions and alkaline metals, the tubes were pre-weighed and pre-washed with 5% nitric acid before the experiment began. The polyethylene mounted tubes were separated into four groups: Group 1 (n = 5) consisted of control tubes that were empty, Group 2 (n = 10) contained tubes that were filled with Sealapex, Group 3 (n = 10) contained tubes that were filled with MTA Fillapex, and Group 4 (n = 10) contained tubes that were filled with White MTA.

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In accordance with the directions provided by the manufacturer, fresh mixed sealers were made. The lentulo spiral assisted in transporting the MTA mixture into the HDPE tube where it was stored. Following the completion of the process of filling the tubes, the materials were compacted using hand pluggers in order to prevent any voids from forming in the inserted sealer. After that, the samples were radiographed, and the ones that were found to have voids in them were thrown away.

After that, the samples were transferred into polypropylene flasks that each held 10 ml of deionized water. The flasks were then sealed. The deionized water was tested to ensure that it did not contain any calcium ions and had a pH level that was not acidic or basic (6.8). The cover was used to seal the flask, and the samples were kept in an incubator at a temperature that was maintained at 37 degrees Celsius during the entirety of the testing period. The pH of the deionized water was determined after 24 hours, 7 days, and 1 month using a pH meter, and the amount of calcium ions that were released was determined using an atomic absorption spectrophotometer. After each round of testing, the water was discarded, and the samples were submerged in an equal volume of new, deionized water (10 ml).

Analysis using statistics According to the normality test, the data was statistically analyzed by the One-Way ANOVA and Post-Hoc Tukey HSD tests using SPSS software (Version 21.0; SPSS, Inc., Chicago, IL). The significance level was set at 5%. This was done in order to compare the materials that were put to the test.

Results

After 24 hours, after 7 days or 1 week, and finally after 30 days or 1 month, all of the materials were analyzed in this study for their ph levels as well as their calcium release. These measurements were taken at three different time intervals.

Table 1 presents a comparison of the findings of the mean pH values obtained from each of the research groups. White MTA (group 4) had the highest mean pH values recorded at 24 h with 8.11, followed by Sealapex (group 2) with 8.33 and MTA fillapex (group 3) with 8.25. These findings were based on the findings of our research. The MTA fillapex had the highest mean pH values measured after 7 days and after 30 days, with 8.62 and 8.72, respectively. The pH of White MTA and sealapex were not significantly different from one another according to the statistical analysis. The difference in values between the MTA Fillapex group and the other two groups was substantially larger than expected (P=00001).

Table1: Comparitive pH Values of Study Materials at 24Hours, 7Days and 30Days.

Study Groups	Mean pH Values 24hrs	Mean pH Values 7Days	Mean pH Values 30Days
Group1(N=5)	6.45±0.12	6.54±0.12	6.87±0.11
Group2(N=10)	8.33±0.23	8.42±0.14	8.43±0.13
Group3(N=10)	8.25±0.05	8.58±0.18	8.71±0.23
Group4(N=10)	8.14±0.04	8.52±0.20	8.58±0.11

In the following table 2, the mean values of calcium release were shown for each of the research materials. It was discovered that White MTA (group 4) had the maximum calcium ion release at 24 hours with a value of 15.1followed by group 2, i.e. Sealapex, which had a value of 9.14, and finally the MTA Fillapex (group 3) sample, which had the lowest values with 6.18. Ca++ emission was undetectable in the control group at any and all time periods. Ca++ release was observed at every time point in every one of the experimental materials. MTA Fillapex had the largest Ca++ release with 9.14after 7 days, whereas Sealapex shown the substantially lowest calcium ion release with 8.12after the same amount of time. After 30 days, the calcium ion release that was caused by MTA Fillapex was once again the highest, coming in at 18.46. It was determined that the difference in the values of MTA Fillapex when compared with those of other groups was statistically extremely significant (P<00001).

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Table2: Comparitive Mean Calcium Values of Study Materials at 24Hours, 7Days and 30Days.

Study Groups	Mean Values 24hrs	Mean Values 7Days	Mean Values 30Days
Group1(N=5)	0.04±0.02	0.05±0.12	0.11±0.02
Group2(N=10)	9.14±0.12	8.12±0.23	6.84±0.18
Group3(N=10)	6.18±0.10	9.14±0.34	18.64±2.20
Group4(N=10)	15.10±0.23	8.32±0.23	9.86±2.12

When the pH and calcium ion release at various time intervals were evaluated, it was discovered that Seal apex exhibited a nearly constant pH and a steady decline in calcium ion release as the time intervals increased. This was the case even though the pH remained relatively the same. In the research that we conducted, MTA Fillapex demonstrated both a rise in the pH and a much larger release of calcium ions when the duration was prolonged.

Discussion

The current study evaluated the changes in ph and calcium release that occurred over the course of three distinct time periods in three different regularly used materials. These materials were Sealapex, MTA Fillapex, and White MTA.

In terms of the pH, our research found that MTA fillapex kept an alkaline ph even after the trial had been conducted for a whole month. However, there are disagreements among the research when the relevant literature is looked at. Several investigations agreed with our conclusion that the extremely alkaline conditions (pH range 10-12) that persisted for four weeks after the first setting.13-15.

Another research found that the initial pH of MTA-Fillapex was somewhat alkaline (pH = 9.3) but that it steadily became more acidic over time, reaching 7.76 after 7 days of testing.16

It was previously thought that a high alkaline pH may encourage a prolonged setting time, which in turn enhances a long-lasting antibacterial effect and eliminates the residual microbes that survive on the dentinal wall. However, recent research has shown that this theory is not supported by the data. 17 On the other hand, the pH value that was discovered in this research turned out to be lower than what Torabinejad et al. and Cutajar et al. had stated. 18

Different formulations of MTA produce different pH values, which can be explained by the fact that calcium hydroxide, which is present in MTA and MTA-based sealers, dissociates into Ca++ and OH ions, thereby increasing the pH of the solution. Additionally, because of the variation in the concentration of calcium hydroxide, there is also variation in pH. This is because calcium hydroxide causes the pH of the solution to change. In addition, despite the fact that both White MTA and MTA Fillapex are sealers based on MTA, the length of the polymer chain that is generated after the sealer has been set might be different, which may be the cause of the different results.

MTA Fillapex showed higher Ca++ release, which can be explained by the higher solubility of MTA Fillapex as was seen in the study by Borges et al. where the solubility of MTA Fillapex (14.85%) was more than Sealapex (5.65%). Further, in our study, MTA Fillapex showed higher Ca++ release, which can be explained by the higher solubility of MTA Fillapex. 19 According to the findings of a study carried out by Nassari MRG et al., the solubility of Fillapex was 16.6% after two days and 15.03% after seven days, whereas the solubility of Sealapex was 13.42% after two days and 9.97% after seven days. 20 A decrease in solubility should be accompanied by a reduction in the amount of Ca++ released as well as a drop in pH.

The setting time and the solubility are two factors that have a direct influence on the calcium ion release and, as a result, the increase in pH values. 21. The presence of calcium may favor an alkaline pH, which leads to a biochemical impact that speeds up the healing process, as stated by Parirock and Toribinejad in their study 22.

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In 2013, Silva et al. reported that because MTAFillapex had a high alkalinity,16 it had a significant ability to release hydroxyl ions, which caused a high Ca2+ ion release. This was owing to the fact that it caused a high Ca2+ ion release. The alkaline medium has the potential to activate the alkaline phosphatase enzyme, neutralize the acid, inactivate the osteoclasts, stop the further destruction of bone tissue, and permit the creation of apatite while simultaneously allowing tissue healing. The high alkalinity, on the other hand, has the potential to cause significant tissue cytotoxicity over time. It was established that the varying alkaline pH values of the four brands of CSS by the considerable difference in the amount of Ca2+ that was released. 16

Conclusion

MTA Fillapex demonstrates better alkalinizing ability and Ca++ release when compared to White MTA and (Sealapex) with an increase in time intervals. This finding, which can be explained by the greater solubility of MTA Fillapex with time when compared to the other two materials, has been shown to be the case. However, more research is required to develop stronger and more validated findings using a technique that may potentially more accurately imitate clinical settings. This should be done before any conclusions can be drawn.

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