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Original Research Article

# Evaluation of flow, Ph and solubility of a new calcium silicate-based sealer: A comparative in-vitro study

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ABSTRACT

**Background:** The physical properties of sealers were evaluated for flow, setting time, radiopacity, dimensional stability, PH change, and solubility. Thus, the aim of this study was to compare a new calcium silicate-based sealer (Ceraseal) with 2 well established root canal sealers (MTA Fillapex & AH Plus) based on their flow, alkalinity and solubility.

**Materials and Methods:** Three already established root canal sealers (MTA Fillapex, Ceraseal & AH Plus) were assessed for flow, alkalinity and solubility among 40 samples. For flow evaluation and pH evaluation 15 samples each were used, and for solubility test 10 samples were used. Statistical analysis was performed using t test and Tukey parametric tests after evaluating the normality of data. The significance level was set at 5%.

**Results:** AH plus showed maximum flow among all the sealers followed by MTA fillapex and Ceraseal. It was found that maximum pH was seen among ceraseal root canal sealer at 72 hours. When MTA Fillapex and ceraseal were compared the results were not significant statistically, except at 72 hours. The maximum solubility was seen among ceraseal sealer followed by MTA Fillapex and AH Plus. The results were significant statistically.

**Conclusion:** Ceraseal had acceptable flow and an alkaline pH while also having a greater solubility, which may be a sign of its bioactivity given the limits of this in vitro investigation.



## 1. Introduction

By thoroughly cleaning and filling the root canal space, endodontic treatment's main objective is to prevent and treat apical periodontitis.[1] Due to the intricacy of the root canal system, it is impossible to provide a sterile environment; thus, the root canal system must be filled and sealed in order to stop leftover microbes and their byproducts from entering the peri-radicular tissues.[2] The "single-cone method" (SCT) is one of several obturation treatments that use gutta-percha and a root canal sealer to close the root canal space.[3] One gutta-percha cone is used predominantly in this approach, and the sealer, which serves as a root canal filler, is given more attention. SCT is thought to be less technique-sensitive and cost-effective than other root-filling methods.[4]

The majority of available sealers, however, tend to shrink after setting, therefore a higher sealer volume inside the root canal space may have a detrimental effect on the seal.[5] As a result, it was determined that SCT in combination with traditional sealers was ineffective, and up to this point, it was advised to use thermoplasticized gutta-percha obturation procedures to increase gutta-percha volume and decrease sealer thickness.[6] Due to their superior biological qualities, silicate-based materials have been employed extensively in endodontic operations since the invention of

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mineral trioxide aggregates.[7] The handling and viscosity characteristics of bio ceramic root canal sealers (BRCS)[8] are also distinctive features that are tailored for obturation of the root canal space.

Dental clinics typically utilise a variety of sealers. Zinc-oxide eugenol, Ca (OH)2, glass ionomer, epoxy or methacrylate resin-based sealers, as well as the more contemporary calcium silicate-based bioceramic (CSBC) sealers, are the most well-known sealants.[9] Modern CSBC sealers are also said to possess the well-established biocompatibility and bioactivity of diand tricalcium silicate cements.[10] The popularity of mineral trioxide aggregate (MTA) materials, a water-setting hydraulic powder utilised for different surgical and vital pulp therapy procedures, led to the development of CSBC sealers.[11–13] The high bioactivity of MTA-type polymers and their hydrophilicity make this type of root canal sealer appealing.[14–16] Paste-based methods utilising GP master cones and CSBC sealers have recently attracted more and more attention. In previous studies, the physical properties of sealers were evaluated for flow, setting time, radiopacity, dimensional stability, PH change, and solubility.[16–18] Thus, the aim of this study was to compare a new calcium silicate-based sealer (Ceraseal) with 2 well established root canal sealers (MTA Fillapex & AH Plus) based on their flow, alkalinity and solubility.

## 2. Materials and Methods

Three already established root canal sealers (MTA Fillapex, Ceraseal & AH Plus) were assessed for flow, alkalinity and solubility among 40 samples. For flow evaluation and pH evaluation 15 samples each were used, and for solubility test 10 samples were used. For flow evaluation, volume of 0.05 ± 0.005 ml of mixed sealer was prepared and placed the centre of a glass plate (40 x 40 x 5 $mm^3$). After 180 ± 5 seconds, a second glass plate weighing 20gm was placed centrally on top of the sealer and a total mass of 120 gm was applied on the first plate. After 10 minutes, the minimum and maximum diameters of the compressed sealer discs were measured using a digital calliper. For pH evaluation, polyethylene tubes measuring 1.6 mm in diameter and 10 mm in height were filled with different experiment sealers. Each specimen was immersed in a glass vial with 10ml of distilled water. The pH measurements were performed at 24 ± $2^0$ C after incubation at $37^0$ C for 3, 24, 72, and 168 hours using pH meter. For solubility test, custom-made stainless-steel ring molds with an internal diameter (20 ± 1) mm diameter and a height of (1.5 ± 0.1) mm. Placed on a glass plate, and the sealers were plugged into the molds. All the specimens were stored in a dark container at $37^0$ C and 95% relative humidity for 72 hours. Filled molds were weighed 3 times before aging immersion period in 50ml distilled water for 24 hours. Filled molds were weighed again 3 times and the mass of the cements was determined as 0.0001 gm. The difference of mass between the initial weight and the final weight was recorded as percentage to determine the solubility percentage of each sealer.

Statistical analysis was performed using t test and Tukey parametric tests after evaluating the normality of data. The significance level was set at 5%.

## 3. Results

**Table 1:** Comparison of flow of Root canal sealers

| Group | Mean | SD | P value |
|---|---|---|---|
| MTA Fillapex | 25.18 | 0.29 | |
| Ceraseal | 22.97 | 0.24 | <0.01 |
| AH plus | 27.67 | 0.33 | |

epicted that AH plus showed maximum flow among all the sealers followed by MTAfillapex and Ceraseal. The results were significant statistically. Comparison of pH of sealers at different intervals was shown in table 2. It was found that maximum pH was seen among ceraseal root canal sealer at 72 hours. When MTA Fillapex and ceraseal were compared the results were not significant statistically, except at 72 hours. In table 3 comparison of solubility of sealers after 24 hours was shown. The maximum solubility was seen among ceraseal sealer followed by MTA Fillapex and AH Plus. The results were significant statistically.

## 4. Discussion

Establishing consistent evaluation procedures for the physicochemical characteristics of cutting-edge and industry-recognized root canal sealers is crucial. To accurately repeat results and compare data collected from other studies, care must be used. Root canal sealers should have their physical and chemical characteristics assessed using procedures that adhere to ADA standard 57[19] and ISO 6876.[20] In this study, a new calcium silicate-based sealer was compared to an AH plus sealer and an MTA-based sealer and evaluated for flow, solubility, and pH. (MTA Fillapex).

The capacity of endodontic sealers to cover abnormalities and holes in the root canal system and create a hermetic seal depends on their flow velocity, which is a crucial characteristic.[21] Although a high flow rate is preferred, over a certain threshold, it may lead to the extrusion of sealer into the tissues surrounding the apex, which could have a negative impact on the effectiveness of root canal therapy.[22,23] In contrast, a low flow rate impairs the international standard's handling characteristics.[24] All of the sealers that were examined in this study provided flow rates that complied with ISO 6876 standard, supporting earlier studies.[25] It's possible that AH plus's superior flow in this study is related to its resin component, which provides plasticity.[26] The flow rate for MTA Fillapex and Ceraseal recorded in this investigation is consistent with that found

**Table 2:** Comparison of pH of sealers at different intervals

| Group | 3 hours | 24 hours | 72 hours | 168 hours |
|---|---|---|---|---|
| MTA Fillapex | 10.07 ± 0.15 | 10.48 ±0.11 | 10.38 ± 0.11 | 10.78 ± 0.10 |
| Ceraseal | 10.78 ± 0.10 | 11.12 ± 0.14 | 11.43 ± 0.12 | 11.32 ± 0.10 |
| AH plus | 8.59 ± 0.12 | 7.81 ± 0.11 | 7.91 ± 0.13 | 8.11 ± 0.19 |
| | | P value | | |
| MTA Fillapex vs Ceraseal | 0.007 | 0.009 | <0.01 | 0.023 |
| MTA Fillapex vs AH Plus | <0.01 | <0.01 | <0.01 | <0.01 |
| Ceraseal vs AH Plus | <0.01 | <0.01 | <0.01 | <0.01 |

**Table 3:** Comparison of solubility of sealers after 24 hours

| Group | Mean | SD | P value |
|---|---|---|---|
| MTA Fillapex | 1.43 | 0.15 | |
| Ceraseal | 3.47 | 0.18 | <0.01 |
| AH plus | 0.48 | 0.09 | |

for other BioCeramic sealers (23-29mm).[24]

Either the American Dental Association (ADA) specification No. 57 or ISO 6876:2012[19,20] can be used to test the flow characteristics of endodontic sealers. The volume of sealer used to quantify flow values differs between the ADA and ISO standards by 0.5 mL and 0.05 mL, respectively. The lowest permissible flow value is 20 mm according to both standards. According to certain studies, the ADA guideline states that the least permissible value should be 25 mm.[27] If the other factors (such as the mass load, plate size, and time) are the same, the amount of sealer utilised may in fact affect the material's flowability. This could help to explain why other research' flow values were higher when utilising the ADA standard.[27,28]

Solubility is straightforwardly related to the dissociation of material components by contact actions with surrounding fluids, creating gaps that could be colonized by microorganisms and lead to reinfection. Root canal sealers should present solubility less than 3%[19,20] in order to maintain their sealing ability and avoid reinfection.[29] In the present study, the solubility of Ceraseal (3.47%) was significantly higher than that of AH Plus (0.48%) and MTA Fillapex (1.43%) ($p<0.05$) and did not meet the minimum requirements of ISO 6876:2012 which is in agreement of previous studies.[30–33]

In the previous studies, the solubility of AH Plus was determined to range between 0.045% and 0.8%[30,34] which is in accordance with results of our study. MTA-based sealers have been reported to fulfill the requirements of the International Standard Organization 6876, demonstrating a weight loss of less than 3%.[32] High solubility of Bioceramic sealers occurs as the result of hydroxyapatite nanosized particles which increases their surface area and allows more liquid molecules to come in contact with the sealer. Moreover, release of calcium ions can be correlated with high initial solubility of Bioceramic sealers However, literature contains conflicting results when it comes to solubility of various Bioceramic sealers: MTA Fillapex solubility was in range of 0.452 to 1.76% after 24hrs in a study by Zhou et al.[16] whereas Gandolfi et al. reported the solubility in range of 11.1 to 14.24%.[35] Ceraseal solubilty was found to be 10.72% after 24hrs in a study by Kharouf et al.[33] The variety in MTA Fillapex solubility may be explained by the fact that it hardly sets completely under different conditions. In a study, MTA Fillapex was unable to set within 1 week in a dry environment or did not set completely after one week even when stored at 37 degree Celsius and 95% relative humidity.[36,37] It may be speculated that in studies where a high solubilty was reported, the setting of MTA Fillapex may be incomplete whereas in the present study a proper initial setting was allowed. The discrepancy between the findings of different studies concerning solubility might be attributed to variations in methods used eg, to dry the samples after having subjected them to solubility testing.[33]

pH change of the root canal sealers leads to their osteogenic potential, biocompatibility, and antibacterial ability. In the present study, the calcium silicate-based sealers exhibited significantly higher pH values than the epoxy resin-based sealer in all experimental periods with Ceraseal exhibiting the highest pH (10.78-11.32). Similarly, Zhou et al.[16] found lower pH values for the AH Plus in comparison with two bioceramic sealers. Sealer Plus BC presented an alkaline pH (ranging from 9.09 to 10.05) that remained stable for 168 h (7 days). The alkalizing effect can be explained by the presence of calcium hydroxide in the matrix composition of this material and result of hydration process. Accordingly, the results for the pH values for the bioceramic sealer and AH Plus in this study were similar to those reported by Khalil et al.[24] In another study by Lee et al.[18] the pH value of three different bioceramic-based root canal sealers remained significantly higher than

that of epoxy resin-based sealers for 24 hours, with the highest alkaline pH measured from BC Sealer for the entire period of evaluation.[38]

## 5. Conclusion

Ceraseal had acceptable flow and an alkaline pH while also having a greater solubility, which may be a sign of its bioactivity given the limits of this in vitro investigation. The optimal balance between the solubility and bioactivity of bioceramic sealers would be determined by more clinical trials and long-term follow-up research.

## 6. Source of Funding

None.

## 7. Conflicts of interest

There are no conflicts of interest.

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