RESEARCH ARTICLE

Time-dependent Evaluation of the pH of Three Different Sealers

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Abstract

Aim: The aim of this study was to evaluate the pH of three different sealers—BioRoot RCS, Sealapex, and AH-plus at different time periods.

Materials and methods: The diluted sealer was transferred to a clean dry test tube. The pH of the root canal sealers was assessed using a digital pH meter. The measurement was carried out at 37°C fluid temperature for all the samples to simulate the oral temperature. The pH measurements were carried out at the end of mixing time (0 hours), 4 hours, 8 hours, and at 24 hours before renewal of the test liquids. Statistical analysis was done using *t* test—comparison of two independent means. The statistical analysis was done using the *post hoc* tests.

Results: The results of the study show that all the three sealers tested were alkaline in nature throughout the test periods. All the sealers showed a significant change during the time periods ($p < 0.05$). AH-plus showed a gradual reduction in pH within the range of 10–10.5. There was a statistically significant change at all time intervals between AH-plus and BioRoot RCS ($p < 0.05$), but no difference between Sealapex and BioRoot RCS or AH-plus ($p > 0.05$).

Conclusion: All the three sealers used in this study are alkaline in nature, with BioRoot RCS showing the highest pH and AH-plus displaying the lowest with a significant difference between the two. There was no significant difference between BioRoot RCS and Sealapex at all time periods.

Clinical significance: The antimicrobial activity of sealer is directly related to pH of sealer. The pH of three sealers—BioRoot RCS, Sealapex, and AH-plus are in the alkaline range up to 24 hours. Bioceramic sealer and Sealapex show the highest pH with no significant difference between them.

Keywords: Bioceramic sealer, Epoxy resin sealer, pH, Root canal sealers.

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Introduction

One of the main objectives of endodontic treatment is to eliminate microorganisms from the root canal system. Persistence of microorganisms in the root canal following endodontic treatment is associated with posttreatment disease.[1] Root canal sealers with antimicrobial properties may contribute to the elimination of the remaining microorganisms or to prevent recontamination. New sealers have been developed with different physiochemical properties in an attempt to develop a biocompatible sealer with the ideal physical, chemical, and mechanical properties. The antibacterial activity of root canal sealers can be partly attributed to its ability to maintain a high pH through a release of hydroxyl ions in an aqueous environment.[2–5] The bioactivity of a root canal sealer is also based on the capacity for releasing calcium ions and maintaining a high pH for a long period of time.[6] Bacteria can produce acids such as lactic acid and reduce the pH of the environment, making it favorable for their survival. The alkalinity provided by sealer can reduce this favorable environment, thereby inhibiting bacterial growth.

Various kinds of endodontic sealers are available, including sealers based on a glass ionomer, zinc oxide–eugenol, resin, calcium hydroxide, silicone, and bioceramic-based root canal sealers. Except the first group, the other class of sealers are more frequently used and studied.[2,4,5,7,8] Bioceramics are a combination of calcium silicate and calcium phosphate that are applicable for medical and dental therapeutic purpose. Bioceramic-based sealers containing calcium silicate shows some additional advantages because of their physical and biological properties such as their alkaline pH, strong antibacterial activity, chemical stability, and being shrinkage free.[8]

The sealers used in this study are of different bases, namely BioRoot RCS (bioceramic-based, Septodont, St. Maur-des-Fosses, France), Sealapex (calcium hydroxide based, Sybron-Endo, Glendora, CA, USA), and AH-plus (Dentsply, DeTrey GmbH, Konstanz, Germany). The aim of this study was to evaluate the pH of the above-mentioned sealers at different time periods.

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Materials and Methods

After proper mixing according to the manufacturer's instructions, 1 mL of each sealer was taken into a syringe, to which 10 mL of deionized water was added. The diluted sealer was transferred to a clean dry test tube. The pH values of the root canal sealers were assessed using a digital pH meter (Susima Technologies Private Limited, Chennai, India). Before each pH measurement, the accuracy of the pH meter was controlled with calibration

solutions (pH 4, 7, and 10; Certipur® Buffer Solutions, Sigma Aldrich, India). After each measurement, the electrode was cleaned with double distilled water to avoid contamination of the fluid between measurements. The measurement was carried out at 37°C fluid temperature for all the samples to simulate the oral temperature. The pH measurements were carried out at the end of mixing time (0 hours), 4 hours, 8 hours, and at 24 hours before renewal of the test liquids. Statistical analysis is done using *t* test—comparison of two independent means. The statistical analysis was done using the post hoc tests.

Results

The results of the study show that all the three sealers tested were alkaline in nature throughout the test periods (Table 1). All the sealers showed a significant change during the time periods ($p < 0.05$). Among the sealers, BioRoot RCS had the highest pH from the start of the mix to up to 24 hours, while Sealapex had the least pH immediately after mixing but showed a gradual increase to a pH that was almost at par with BioRoot RCS at 24 hours (Fig. 1). AH-plus showed a gradual reduction in pH within the range of 10–10.5. There was a statistically significant change at all time intervals between AH-plus and BioRoot RCS ($p < 0.05$), but no difference between Sealapex and BioRoot RCS or AH-plus ($p > 0.05$) (Table 2).

Discussion

One of the distinguishing quality of *E. faecalis* is its ability to resist alkaline pH, which normally inhibits other microbes.[9,10] It has been shown that *E. faecalis* can resist a pH of 11.0 but gets killed only if the pH is 11.5.[11] Therefore, it is important that the pH of a sealer should be as high as possible to eradicate the persistent microbes which had survived chemomechanical preparation. The results of this study shows that the pH of all the three sealers tested is alkaline, with the pH of BioRoot RCS being the highest and AH-plus sealer the lowest with a mean of 11.74 and 11.64 respectively after 24 hours. While BioRoot RCS and Sealapex showed a gradual increase in pH over the period of 24 hours, AH-plus showed a slight fall although it remained in the alkaline range, which is consistent with previous studies.[2,5,9–11] The pH value of AH-plus was similar in the study by Zhou et al., while other studies showed a much lower value.[2,5,9] Though the mean pH value of AH-plus has declined over time and is the lowest at 24 hours, it has shown a strong antibacterial property to both planktonic and biofilms forms.[12] This shows that the pH of AH-plus may not contribute much towards its antibacterial property, but AH-plus, being an epoxy-resin-based sealer, can be toxic to bacteria because of its formaldehyde release during setting or bisphenol A diglycidyl ether.[13,14]

According to the manufacturer's claim, BioRoot RCS has a pH that is close to 12 at 24 hours, which is in concurrence with our result (mean of 11.74). Previous studies have shown that the pH values of BioRoot RCS were the range from 11.7 after 3 hours[9] to about 11–12 after 1 day,[8,15–17] which also concurs with this study. The presence of such a high pH is clinically advantageous as it may contribute to their osteogenic potential, biocompatibility, and antibacterial ability.[8] The increase in pH could be attributed to high solubility of the sealer, which was confirmed in previous studies with an increase in calcium ion release over time.[2,10] Urban et al. had shown that while the pH was high, the solubility of BioRoot RCS also increased during a period of 6 months, but it was less than 3% after 6 months as required according to ISO standards.[5] A high pH during setting may contribute to periapical healing as it may alkalinize the periapex, which would have been acidified because of inflammation. It may also activate alkaline phosphates and osteoblast cell metabolism favors deposition of mineralized tissue.[5] It has been postulated that moisture facilitates dissolution of sealer to produce hydroxyl ions and calcium silicates. The hydration of this calcium silicates by the tissue fluids produces calcium silicate hydrogel and calcium hydroxide, which combines with phosphate to form hydroxyapatite, which contiues to form up to two months.[18] The hydroxyl ion is responsible for the pH observed in this study and hydroxyapatite formation from the calcium hydroxide is as follows:[8]

$$7Ca(OH)_2 + 3Ca(H_2PO_4)_2 / Ca_{10}(PO_4)_6(OH)_2 + 12H_2O$$

Table 1: pH at different time intervals (Sig $p < 0.05$)

Sealer	*AH-plus*	*Sealapex*	*BioRoot RCS*
pH—at mixing	10.46 ± 0.0554	8.96 ± 1.36	11.09 ± 0.0385
pH—after 1 hour	10.38 ± 0.0532	11.04 ± 0.2197	11.41 ± 0.0572
pH—after 2 hours	10.28 ± 0.0415	11.26 ± 0.0869	11.51 ± 0.0336
pH—after 4 hours	10.17 ± 0.0378	11.47 ± 0.0832	11.64 ± 0.0251
pH—after 24 hours	10.07 ± 0.0427	11.56 ± 0.0537	11.73 ± 0.0356

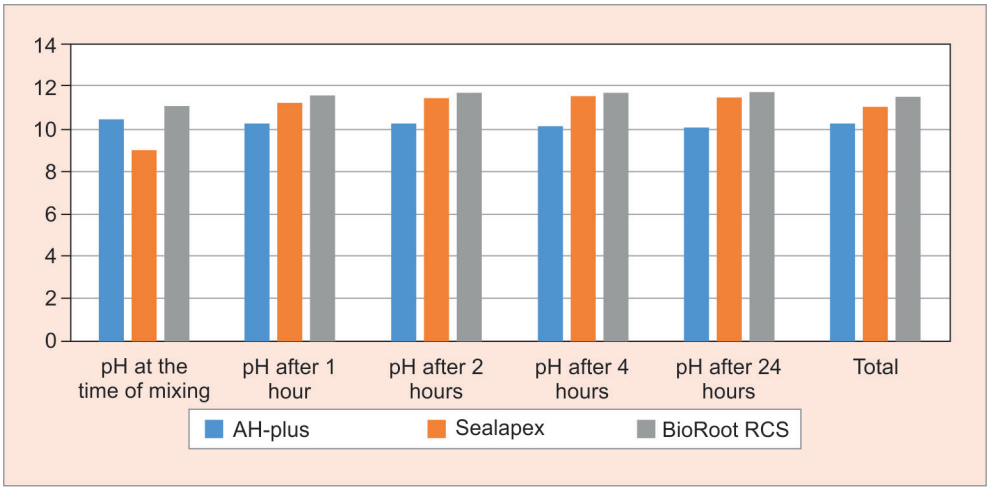

Fig. 1: pH at different time intervals

Table 2: Comparison of mean difference of pH value after 24 hours (Sig $p < 0.05$)

Sealer		*pH at 24 hours (mean ± SD)*	*Mean difference*	*t value*	*p value*
AH-plus (10.07 ± 0.0427)	Sealapex	11.56 ± 0.0537	−1.49	−48.40274	<0.0001
	BioRoot RCS	11.73 ± 0.0356	−1.66	−66.77499	<0.0001
Sealapex (11.56 ± 0.0537)	BioRoot RCS	11.73 ± 0.0356	−0.17	−6.10905	0.000287

Sealapex has shown to have a good antibacterial action, both immediately and after several days.[2,18] The performance of Sealapex is partially attributed to its ability to maintain a high pH in the adjacent medium for extended periods of time.[10] The increase in pH of Sealapex in this study could be attributed to high solubility of the sealer with an increase in calcium ion release over time.[2,10] Dissolution of root canal sealer may cause leakage of bacteria and toxins through the gap formed in the sealer–dentin or the sealer–gutta-percha interface. Though the solubility is high, the calcium ions released by endodontic sealers may combine with phosphate to promote the formation of a superficial layer of hydroxyapatite, which is able to fill open voids originated by the high solubility.[6,15] A high pH also contributes to osteogenic potential, biocompatibility, and antibacterial ability of root canal sealers, all of which are important for long-term success of endodontic treatment.[9]

Conclusion

Within the limitations of this study, it can be concluded that all the three sealers used in this study are alkaline in nature, with BioRoot RCS showing the highest pH and AH-plus the lowest with significant difference between the two. There was no significant difference between BioRoot RCS and Sealapex at all time periods.

Clinical Significance

The antimicrobial activity of sealer is directly related to the pH of sealer. The pH of three sealers—BioRoot RCS, Sealapex and AH-plus—are in the alkaline range upto 24 hours. Bioceramic sealer and Sealapex show the highest pH with no significant difference between them.

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