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Research Article

Comparison of CEM Cement Solubility in Acidic and Neutral Environments: An *In-Vitro* Experiment

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Abstract

Background and purpose: The solubility of root end filling materials is strongly affected by the environment they are in contact with. The aim of this study is to compare the solubility of CEM cement in two neutral and acidic environments.

Materials and Methods: 40 metal rings filled with CEM cement were prepared and were randomly divided into two groups. Samples in groups 1 and 2 were placed in artificial interstitial fluid with pH = 7.4 and pH = 4.4 and then were transferred into bottles containing distilled water with pH = 7.4 and pH = 4.4. Solubility of CEM cement samples were calculated in two time periods. Data were analyzed using independent t-test.

Results: The results of this study showed the level of solubility in acidic group on both days 7 and 28 was more than the neutral group, which was statistically significant (P = 0.001).

Conclusion: The solubility of CEM cement in the neutral and acidic environment increases with time. The more acidic the environment, the greater the dissolution.

Keywords: CEM Cement; PH; Solubility; Acidic Environment

Introduction

The nature of different endodontic procedures such as periapical surgery, perforation repair, regenerative treatments, or apexification can cause restorative materials to communicate with inflamed tissues. Inflammation, abscess, or periapical lesions will reduce PH levels [1], thus selection of an appropriate restorative material -which is lesser influenced by acidity of surrounding tissues- would be necessary.

Calcium-enriched mixture (CEM) is a water-based tooth-colored cement with good handling properties. The setting of cement in water-based environments will take less than sixty minutes and can make an effective seal when used as a filling material for an artificial apical barrier [2]. The powder form of the CEM cement has small hydrophilic particles which will harden the cement when it dissolves in water. This hydration process during and at the end of the reaction forms calcium hydroxide (CaOH) which is responsible for the biological features of the CEM cement [3].

The clinical application of CEM cement is believed to be similar to mineral trioxide aggregate (MTA) [4]. The MTA was first proposed for repairing root perforations [5]. Afterward, it was utilized as a filling material in surgical procedures [6], in vital pulp therapy [7], or as an apical plug in apexification [8]. Similar results were observed when MTA and CEM cement were used as a pulp cap, pulpotomy or perforation repair material [9-12]. Evaluation of MTA has revealed that properties such as sealing ability, tensile strength, push-out bond strength, surface hardness, and solubility will be influenced by acidic environments [13]. Changes in the pH level of the host tissue will probably cause changes in the CEM cement's physical or chemical properties, too. It was shown in a study that both acidic and alkaline environments increase the compressive strength of CEM cement [14].

Torabinejad., *et al.* reported that MTA remains soft when is used in perforations with severe inflammations in surrounding tissues. They declared that this happens probably due to the low PH levels which can prevent the proper setting [6]. Another study by Jamali Zavare., *et al*. concluded that addition of alkaline salts such as to MTA and to CEM cement can increase their PH level and calcium ion release and reduce their setting time, subsequently [15].

Dental material's solubility is an important physical property that may affect other features such as microleakage [16]. It is now believed that the success rate of the treatment is influenced by the solubility of materials. Considering the fact that no study has yet investigated the influence of PH levels on CEM cement's properties, we aimed to evaluate the effects of an acidic environment on CEM cement solubility.

Materials and Methods

This study was conducted at faculty of dentistry and pharmaceutical research center of Tabriz University of medical sciences, Tabriz, Iran. Considering the data obtained from Yavari., *et al*. [17] study and assuming an alpha error of 5% and a power of 80%, eighteen specimens were needed for each group of this in-vitro experiment. Finally, 40 specimens were prepared and randomly divided into two equal groups: 1) neutral environment 2) acidic environment.

Sample preparation

Each gram of CEM cement (BioniqueDent, Tehran, Iran) was first precisely weighted with an analytic weighing machine (A × 120 Series, Shimadzu, Japan), accurate to ± 0.0001 g, and mixed with 0.33 ml of distilled water. They were then placed inside a pre-weighed metal ring with an inner diameter of 20 mm and a height of 2 mm according to the ISO no. 6876 Specification. The surface of the material was equalized with the surface of the ring using a cement spatula. The inferior surface of the ring was covered with the glass slab to minimize surface roughness. The specimens were then incubated for 21 h at 37°C and 100% relative humidity. They were stored in vacuum desiccator for 4 (Figure 1) hours and then transferred to an oven (105°C) to reach a constant weight. The analytic weighing machine was then used to measure the initial dry sample's weight by subtracting the rings weight from the total.

Preparation of the neutral and acidic environments

Synthetic tissue fluid was manufactured by the method explained in Rahimi., *et al.* [18] study. The neutral environment was prepared by dissolving 0.5 mol calcium hydroxide in distilled water to reach a PH of 7.4. The second group's pH was adjusted to 4.4 using butyric acid. The pH was controlled by a pH meter.

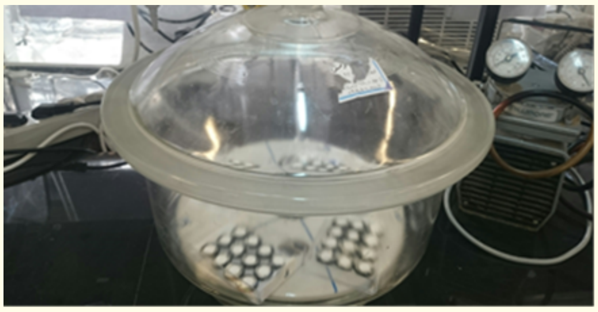

Figure 1

Solubility measurement

Each of the specimens of both groups were placed in a pre-weighed beaker containing 50 ml of synthetic tissue fluid. The beaker was then incubated at 37°C according to the ISO no. 6876 Specification. After 7 and 28 days, samples were took out of the beaker and each sample's surface was washed using distilled water. After rinse at day 7, volume of tissue fluid in the beaker was returned to 50 ml. The samples were then dried by an oven (75°C for 21 hours). The dissolved material's weight was measured by subtracting the initial dry sample's weight from weight of the sample after 7 and 28 days using the analytic weighing machine. The following equation was used to measure the solubility at each interval

Statistical analysis

Commercial software (SPSS 24.0; SPSS Inc., Armonk, New York, USA) was used for statistical analysis. For comparison of the effect of two different environments on solubility of CEM cement, independent t-test was utilized. Significance level was set at <0.05.

Results

The amount of CEM cement solubility in neutral and acidic environments after 7 and 28 days is demonstrated in table 1. After 7 days, solubility in acidic environment was significantly greater than neutral environment (Table 1). The difference was also statically significant after 28 days (Figure 2).

Discussion

Placing calcium silicate-based materials in low pH environments may affect their physical and chemical properties [19]. Results of the current study revealed that the CEM cement's solubility in neutral and acidic environments increased after 7 and 28 days. Furthermore, the amount of solubility was higher in acidic environments. In this study, the acidic environment was prepared using butyric acid, a by-product of the metabolism of anaerobic bacteria which simulates clinical conditions in peri-radicular infections [19]. Considering the existing evidence about the similarity of physical and chemical characteristics between CEM cement and MTA [20], some of the features of MTA can be attributed to CEM cement.

	Group	Number	Average	Standard devtation	P value
Solubility [7]	Natural	20	0.0013	0.0011	001/0
	Acidic	20	0.0276	0.0091	
Solubility [28]	Natural	20	0.0042	0.0050	001/0
	Acidic	20	0.0893	0.0206	

Table 1

	Group	Number	Mean	SD	P value
Solubility in 7th day	Neutral	20	0.0013	0.0011	0.001
	Acidic	20	0.0276	0.0091	
Solubility in 28th day	Neutral	20	0.0042	0.0050	0.001
	Acidic	20	0.0893	0.0206	

Table 2: Degree of solubility in neutral and acidic groups on the 7th and 28th

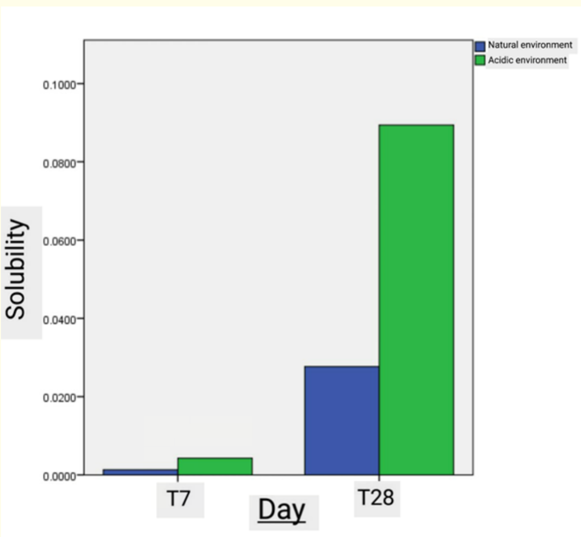

Figure 1

In 2011, Saghiri., *et al*. conducted a study to compare the solubility of MTA in tissue fluid and deionized water after 7 and 28 days. They observed that the solubility increases through time, and is higher in deionized water [21]. Their results were compatible with the results of the present study. In another study, they investigated the effect of PH on the solubility of different cement materials. They concluded that the solubility differs in different environments, in which, acidic environments lead to the most solubility [22]. The CEM cement's solubility in both groups of this study also increased after 7 and 28 days, and its amounts were again higher in acidic environments. Shojaee., *et al*. [23] revealed that weight changes in CEM cement and MTA are similar. Therefore, we can attribute the solubility of MTA to CEM cement. Namazikhah., *et al*. [19]. Examined their samples with a scanning electron microscope (SEM) and observed that MTA shows higher porosity in low pH conditions.

Although no similar study has been conducted yet to evaluate the effect of pH on the solubility of CEM cement, Shojaee., *et al.* [23] also evaluated the solubility of CEM cement and MTA after 7 and 28 days. They observed a weight gain on the 28th day in both types of cement. These researchers have used phosphate-buffered saline (PBS), which acts as a confounder and increases the weight, while water was used in our study for synthetic tissue fluid preparation. This confounding factor has been proven in previous studies, in which, Biodentine and MTA cements lost weight in the water solution but gained in the PBS solution [24].

Pushpa., *et al*. [25] measured the solubility of white MTA (WMTA) and biodentine in three different environments: neutral, acidic, and alkaline. They observed that both materials had higher solubility in an acidic environment. Also, WMTA had more solubility in the alkaline environment rather than neutral and biodentine had more solubility in the neutral environment compared to alkaline. Considering the similarities in properties of WMTA and CEM cement, the same results are probable.

Effects of other some other variables on the solubility of CEM cement have also been measured. Shahi., *et al*. investigated the effects of different mixing methods and found that although solubility remains within an acceptable range in all three different methods, mechanical mixing led to more solubility than hand- and ultrasonic- mixing in first and 21th day, significantly [26]. Shojaee., *et al*. in 2019 have measured the effect of different water-to-powder ratios. Their results showed a significant difference between CEM cement's solubility values in different water-to-powder ratios [27]. In another study, a significant reduction was observed in the solubility after addition of CaCl2 to CEM cement [28].

Results of multiple studies have shown that MTA will release its soluble components -mainly calcium hydroxide- even in short terms and is affected by the pH of the environment [29,30]. According to the outcomes of this research which indicated higher solubility of CEM cement in the acidic environment, further investigations about the influence of lower PH levels on other features such as radiopacity, setting time, release, micro-leakage, etc. are recommended.

Conclusion

The results of the current study revealed that the solubility of CEM cement will increase by reduction of PH to 4.4. Also, solubility will increase through time in both acidic and neutral environment.

Conflicts of Interest

None.

Authors' Contributions

Author AGH and author MFR have given substantial contributions to the conception or the design of the manuscript, author YR to acquisition, analysis and interpretation of the data. All authors have participated to drafting the manuscript, author AGH revised it critically. All authors read and approved the final version of the manuscript.

All authors contributed equally to the manuscript and read and approved the final version of the manuscript.

Bibliography

1. Nekoofar MH., *et al*. "pH of pus collected from periapical abscesses". *International Endodontic Journal* 42.6 (2009): 534-538.
2. Zavare FJ., *et al*. "Chemical modification of MTA and CEM cement to decrease setting time and improve bioactivity properties by adding alkaline salts". *Journal of Dental Research, Dental Clinics, Dental Prospects* 14.1 (2020): 1.
3. Reyhani MF., *et al*. "Effects of various liquid-to-powder ratios on the compressive strength of calcium enriched mixture". *Journal of Dental Research, Dental Clinics, Dental Prospects* 15.2 (2021): 129.
4. Esmaeili B., *et al*. "Coronal discoloration induced by calcium-enriched mixture, mineral trioxide aggregate and calcium hydroxide: a spectrophotometric analysis". *Iranian Endodontic Journal.* 11.1 (2016): 23.
5. International Organization for Standardization. ISO 6876: 2012-Dentistry: Root canal sealing materials (2012).
6. Torabinejad M., *et al*. "Sealing ability of a mineral trioxide aggregate when used as a root end filling material". *Journal of Endodontics* 19.12 (1993): 591-595.
7. Torabinejad M and Chivian N. "Clinical applications of mineral trioxide aggregate". *Journal of Endodontics* 25.3 (1999): 197-205.
8. Shabahang S and Torabinejad M. "Treatment of teeth with open apices using mineral trioxide aggregate". *Practical Periodontics and Aesthetic Dentistry: PPAD* 12.3 (2000): 315-320.
9. Haghgoo R., *et al*. "Microleakage of CEM cement and ProRoot MTA as furcal perforation repair materials in primary teeth". *Iranian Endodontic Journal* 8.4 (2013): 187.
10. Sharaan M and Ali A. "Mineral Trioxide Aggregate vs Calcium-Enriched Mixture Pulpotomy in Young Permanent Molars with a Diagnosis of Irreversible Pulpitis: A Randomized Clinical Trial". *Iranian Endodontic Journal* 17.3 (2022): 106-113.
11. Manohar S., *et al*. "A comparative evaluation of four regenerative materials for pulpotomy in primary molars: An *in vivo* study". *Dental Research Journal (Isfahan)* 19 (2022): 102.
12. Asgary S., *et al*. "Outcomes of root canal therapy or full pulpotomy using two endodontic biomaterials in mature permanent teeth: a randomized controlled trial". *Clinical Oral Investigation* 26.3 (2022): 3287-3297.
13. Sáez MdM., *et al*. "Evaluation of pH and calcium ion diffusion from calcium hydroxide pastes and MTA". *Acta odontológica Latinoamericana* 30.1 (2017): 26-32.
14. Sobhnamayan F., *et al*. "Effect of different pH values on the compressive strength of calcium-enriched mixture cement". *Iranian Endodontic Journal* 10.1 (2015): 26.
15. Jamali Zavare F., *et al*. "Chemical modification of MTA and CEM cement to decrease setting time and improve bioactivity properties by adding alkaline salts". *Journal of Dental Research, Dental Clinics, Dental Prospects* 14.1 (2020): 1-11.
16. Kaplan A., *et al*. "Disintegration of endodontic cements in water". *Journal of Endodontics* 23.7 (1997): 439-441.
17. Yavari HR., *et al*. "Placement in an acidic environment increase the solubility of white mineral trioxide aggregate". *Journal of Conservative Dentistry: JCD* 16.3 (2023): 257.
18. Rahimi S., *et al*. "Comparison of microleakage with three different thicknesses of mineral trioxide aggregate as root-end filling material". *Journal of Oral Science* 50.3 (2008): 273-277.
19. Namazikhah M., *et al*. "The effect of pH on surface hardness and microstructure of mineral trioxide aggregate". *International Endodontic Journal* 41.2 (2008): 108-116.
20. Utneja S., *et al*. "Current perspectives of bio-ceramic technology in endodontics: calcium enriched mixture cement-review of its composition, properties and applications". *Restorative Dentistry and Endodontics* 40.1 (2015): 1-13.
21. Saghiri MA., *et al*. "A comparative study of MTA solubility in various media". *Iranian Endodontic Journal* 6.1 (2011): 21.

22. Saghiri MA., *et al*. “The effect of pH on solubility of nano-modified endodontic cements”. *Journal of Conservative Dentistry: JCD* 17.1 (2014): 13.

23. Shojaee NS., *et al*. “Solubility of two root-end filling materials over different time periods in synthetic tissue fluid: a comparative study”. *Journal of Dentistry* 16.3 (2015): 189.

24. Keyf F., *et al*. “Water sorption and solubility of different luting and restorative dental cements”. *Turkish Journal of Medical Sciences* 37.1 (2007): 47-55.

25. Pushpa S., *et al*. “Effect of pH on solubility of white Mineral Trioxide Aggregate and Biodentine: An *in vitro* study”. *Journal of Dental Research, Dental Clinics, Dental Prospects* 12.3 (2018): 201.

26. Shahi S., *et al*. “The Effect of Different Mixing Methods on the pH and Solubility of Mineral Trioxide Aggregate and Calcium-Enriched Mixture”. *Iranian Endodontic Journal* 10.2 (2015): 140-143.

27. Shojaee NS., *et al*. “Effect of Different Water-to-powder Ratios on the Solubility and Microhardness of Calcium-Enriched Mixture Cement”. *Iranian Endodontic Journal* 14.3 (2019): 185-189.

28. Abbaszadegan A., *et al*. “Effect of calcium chloride on physical properties of calcium-enriched mixture cement”. *Australian Endodontic Journal* 41.3 (2015): 117-121.

29. Azuma M. “Fundamental mechanisms of host immune responses to infection”. *Journal of Periodontal Research* 41.5 (2006): 361-373.

30. Fridland M and Rosado R. “MTA solubility: a long term study”. *Journal of Endodontics* 31.5 (2005): 376-379.