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Evaluation of Alkalizing Potential of Alkasite Restorations Prepared in Different Sizes

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Research Article

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History

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ABSTRACT

Aim: The aim of the present study was to examine the effect of alkasite material on the pH of the environment when used as a restorative material in different cavity preparations and prepared as a single block in standard sizes.

Methods: Alkalizing potential of the alkasite material was evaluated by restoring extracted teeth with three different restorative materials and preparing edentulous blocks. For this purpose, 30 extracted premolar teeth and silicone molds of standard size (2x2x4 mm) were used. One of the study groups consisted of edentulous alkasite blocks of standard size and the other three groups (O, OM, MOD) were alkasite restorations of cavities of different sizes. The teeth were divided into three groups according to the type of cavity preparation. Restoration of cavities and preparation of the blocks were performed according to Cention N (Ivoclar Vivadent) manufacturer's instructions. All restorations and blocks were immersed individually in distilled water at pH 4. pH measurements were obtained using a pH meter (Sartorius, France) at 10-min, 20-min, 30-min and 60-min timepoints following immersion. Measurements were repeated for all four groups at the end of 24 hours, 48 hours and 7 days.

Results: Alkalizing effect was observed in all groups. pH changes after 24 hours, 48 hours and 7 days showed a significant difference among the groups at the measurement timepoints (p<0.05). Maximum pH increases were seen at 24 hours, and minimum pH changes at 48 hours. Within the first 24 hours, MOD restoration group showed the highest pH values at 60 minutes.

Conclusion: Within the limits of the study design, O, MO and MOD dental restoration groups were associated with a significantly greater pH increase compared to alkasite blocks. The effect of alkasite restorative material alone is not sufficient to provide pH increases above the critical threshold. Ions released from the tooth also seem to have an effect on pH increase.

Key Words: Alkasite, pH change, Demineralization.

Farklı Ebatlarda Hazırlanan Alkasite Restorasyonlarının Alkalize Potansiyelinin Değerlendirilmesi#

Bilgi
#Bu çalışma 23-25 Kasım 2021 tarihleri arasında düzenlenen 'Sivas Cumhuriyet Üniversitesi 1. Uluslararası Diş Hekimliği Kongresi'nde sözlü bildiri olarak sunulmuştur.
**Sorumlu yazar*

Süreç

Geliş: 21/01/2022
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ÖZ

Amaç: Bu çalışmanın amacı alkasit materyalinin farklı kavite preparasyonlarında restoratif materyal olarak kullanıldığında ve standart boyutlarda tek blok olarak hazırlandığında ortam pH'ına etkisinin incelenmesidir.

Yöntem: Bu çalışmada alkasit materyalinin alkalileştirme potansiyeli çekilmiş dişlere üç farklı restorasyon yapılarak ve dişsiz bloklar hazırlanarak değerlendirilmiştir. Bu amaçla 30 adet çekilmiş premolar diş ve standart boyutlarda (2x2x4 mm) silikon kalıplar kullanılmıştır. Grubumuzun birini dişsiz standart boyutlarda hazırlanan alkasit bloklar, diğer üçünü farklı boyutlarda kavitelere (O, OM, MOD) yapılan alkasit restorasyonlar oluşturmaktadır. Bu amaçla dişler kavite preparasyon şekline göre 3 farklı gruba ayrılmıştır. Kavitelerin restorasyonu ve blokların hazırlanması Cention N'nin (Ivoclar Vivadent) kullanım prosedürlerine göre yapılmıştır. Hazırlanan her bir restorasyon ve blok ayrı ayrı pH'ı 4'e düşürülen distile su içerisine atılmıştır. Sırasıyla 10dk, 20dk, 30dk ve 60dk içerisinde pH ölçümleri pH metre (Sartorius,France) ile yapılmıştır. Ölçümler 24 saat,48 saat ve 7 gün sonra olacak şekilde 3 farklı zamanda 4 grup için tekrarlanmıştır.

Bulgular: Bütün gruplarda alkalize edici etki görülmüştür. Ölçüm yapılan bütün dakikalar için 24 saat,48 saat ve 7 günde pH değişimleri gruplar arasında anlamlı olarak farklılık göstermiştir (p<0.05). Maximum pH artışları 24 saatte görülürken, minimum pH değişimi 48 saatte görülmüştür. İlk 24 saat için 60 dakika sonunda en yüksek pH değerleri MOD restorasyon grubuna aittir.

Sonuçlar: Çalışmamız sınırları içerisinde dişe yapılan O, MO ve MOD resyorasyon gruplarının dişsiz bloklara göre pH artırıcı etkisi anlamlı olarak daha fazladır. Kritik seviyeyi geçecek düzeyde pH artışında, tek başına alkasit materyalinin etkisi yeterli değildir. Dişten salınan iyonların da pH artışında etkisinin olduğunu düşünüyoruz.

Anahtar Kelimeler: Alkasit, pH değişimi, Demineralizasyon.

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Introduction

Resin-based composites have become one of the most commonly used materials in dentistry due to the improvement of their mechanical and aesthetic properties.[1] Some difficulties in the placement of composites, requirement for technical precision, incomplete polymerization, and polymerization shrinkage cause mikroleakage at the interface of the restoration and the cavity wall, leading to the development of secondary caries over time.[2] Secondary caries formation, one of the main reasons for the failure of composite restorations, has prompted manufacturers to develop new materials.[3]

Cariogenic foods and beverages contain fermentable carbohydrates which are broken down by oral microorganisms into organic acids, resulting in a decrease in the saliva pH.[4] The critical pH is the pH at which the fluid on the tooth surface is undersaturated relative to hydroxyapatite, allowing calcium and phosphate to dissociate from the enamel. This usually refers to pH values of 5.5 and below. Dissolution of the tooth enamel, i.e., demineralization, begins below the critical pH, and this is the first step in dental caries formation.[5] The oral cavity goes through cycles of remineralization and demineralization continuously. The ratio between remineralization and demineralization determines the strength and hardness of tooth structure. During remineralization, the holes that are formed as a result of mineral dissolution through the demineralization process are filled with minerals, allowing for the restoration of the tooth's mineral content. Repaired crystals are larger than the original crystals. Thus, remineralized enamel becomes less soluble and more resistant to acid attacks.[6]

The majority of the commercially available composite resins have no remineralizing effects.[7] They can only restore cavities following the loss of tooth structure and cannot prevent subsequent complications such as recurrent caries development from the acidic oral environment. There is a growing interest in the use of resin-based bioactive and remineralizing restorative materials to overcome such problems.[8] Different ions are released from these materials upon their interaction with the oral environment. Accordingly, the increase in pH and the induction of hydroxyapatite deposition may reduce the incidence of caries around the restoration margins.[9] Release of fluoride, calcium, and phosphate ions that are involved in tooth remineralization seems to be an integral feature for future restorative materials [10]

Bioactive materials are defined as surface-reactive compounds that elicit a specific biological response by reacting physically, chemically and biologically, and form bonds with the tissue when applied to living tissues. Calcium phosphate compounds, calcium hydroxide, mineral trioxide aggregate, bioactive ceramics, and bioactive glasses used in restorative dentistry are examples of bioactive materials.[11] Bioactive glass materials have several novel properties, and most notably, they have the ability to act as a biomimetic mineralizer, meeting the body's own mineralization needs. Owing to their nanometric particle size, bioactive glass materials are able to release ions faster and increase the remineralization rate.[12]

Cention N is a tooth-colored, bioactive, dual-cure restorative material with high flexural strength, which is supplied in the form of powder and liquid (Table 1).[13] It has been developed to prevent demineralization by releasing acid-neutralizing ions to maintain enamel saturation during the remineralization-demineralization cycle at a low pH. Cention N contains alkaline fillers embedded in a methacrylate resin matrix and releases hydroxyl ions and thus, it can neutralize the pH-lowering activity of acidogenic cariogenic bacteria.[14]

Table 1. Material used in the study

Material	Manufacturer	Composition	Filler
Cention N, alkasite, restorative, material	Ivoclar-Vivadent, Liechtenstein, Switzerland	UDMA, No Bis GMA, No TEGDMA, No HEMA	Barium aluminum silicate glass, Ytterbium trifluoride, Izo filler, calcium barium aluminum fluorosilicate glass, calcium fluorosilicate glass (57.6%)

Ion release and therefore the impact on pH are affected by many factors including the composition of the material, mixing time, temperature, finishing procedures, and environmental conditions.[15] There is no study available in the literature on the effect of the size of restoration made with alkasite material on the pH of the environment. The aim of the present study was to examine the effect of Cention N on the pH of the environment when used as a restorative material in different cavity preparations and prepared as a single block in standard sizes. The alternative hypotheses that were constructed for this purpose were as follows:

- H_0: There is no difference among the alkasite restorations of different sizes in terms of the pH of the environment.
- 2 .H_0: There is no significant difference between restorations prepared as a single, edentulous block and dental restorations in terms of the ability to alkalize the medium.

Material and Methods

Ethics approval for the study was obtained from Sivas Cumhuriyet University Ethics Committee for Non-Interventional Clinical Research Studies on November 17, 2021 (No. 2021-11/16). Teeth to be extracted from adult patients for orthodontic, surgical, or periodontal indications and to be disposed of as medical waste irrespective of the academic research were used with the consent of the patients prior to extraction. The teeth to used in the study were stored at 4°C in a saline solution containing 0.1% thymol crystals to avoid drying and to ensure disinfection.

Group Assignment and Preparation of Samples

Group 1 (Block): Ten silicone molds of standard dimensions (2x2x4 mm) were used for the preparation of the blocks.

For Groups 2, 3, and 4, 30 permanent, non-carious premolar teeth without any restoration were randomly divided into 3 groups (n=10).

Group 2 (O): Occlusal cavities (2x2x2 mm) were created with an aerator under water cooling using diamond burs.

Group 3 (MO): Mesio-occlusal cavities with an occlusal and approximal depth of 2 mm, and 1 mm above the cemento-enamel junction at the approximal were created with an aerator under water cooling using diamond burs.

Group 4 (MOD): Mesio-occlusal distal cavities with an occlusal and approximal depth of 2 mm, and 1 mm above the cemento-enamel junction at the approximal were created with an aerator under water cooling using diamond burs.

Next, the cavities were rinsed with water and dried. Ten silicone molds of standard dimensions (2x2x4 mm) were used for the preparation of the blocks. For restoration of the cavities and preparation of the blocks, Cention N powder and liquid were mixed with a plastic spatula (45- 60 sec) according to manufacturer's instructions at a ratio of 4.6:1 by weight (This ratio is equivalent to 1 drop of liquid for 1 measuring spoon of powder). Working time was 4 minutes after mixing. During that time, Cention N was placed on the teeth and molds by condensation with manual tools without applying any adhesive. Then, self-cure polymerization was achieved without using a light-curing unit. Occlusal adjustments and finishing were done using disc (Sof-Lex, 3M ESPE, St Paul, MN, USA) and silicone rubbers.

pH measurements were obtained using a Sartorius Basic pH meter with an epoxy capped glass electrode. The pH meter was calibrated with standard buffer solutions (pH= 4.0, 7.0, 10.0) purchased from Reagecon (Shannon Free Zone, Ireland). The alkalizing potential of restorations of different sizes was determined based on their ability to increase the pH of the acidified solution. Firstly, the pH of the solution was adjusted to 4.0 with lactic acid. Then, each restoration prepared for this purpose was placed in test tubes containing 5 ml of pH 4.0 solution. Changes in pH of the solutions were assessed at the intervals of 10 minutes, 20 minutes, 30 minutes and, 60 minutes, respectively.

In order to evaluate the alkalizing potential at different timepoints, measurements were repeated at 24 hours, 48 hours, and 7 days for all 4 groups. Data on pH changes at all time intervals tested were statistically analyzed at the significance level of 0.05.

Statistical Analysis

Data from the study were analyzed using SPSS software, version 22.0 (IBM Corp., Armonk, NY). The normality of data distribution was checked using the Kolmogorov-Smirnov test. The variables with a normal distribution were analyzed with the F test (ANOVA). Since the data met the assumption of homogeneity of variances on the post hoc test, Tukey's HSD (honestly significant difference) test was used to determine which group differed from the others when testing more than two groups. For the variables with a non-normal distribution, the Kruskal-Wallis test was used to compare measurements from multiple groups, and the Mann-Whitney U test was employed to determine the difference between paired groups. The error level was set at 0.05.

Results

Assessment of pH measurements taken 10 minutes after acidification of the medium at 24 hours, 48 hours and 7 days of restoration

The difference in pH measurements obtained 10 minutes after acidification of the medium at 24 hours, 48 hours, and 7 days was significant among the restoration groups. The samples prepared as a single, edentulous block showed significantly lower pH values at 24 hours when compared with MO and MOD groups, and at 48 hours compared to O, MO and MOD groups and 7 days. For the restored teeth, a significant difference was found in pH values between O and MO and between O and MOD groups at 48 hours, and between O and MO groups at 7 days ($p<0.05$). The highest pH value was observed in the MO restorations at the end of 7 days. The 10-min data are presented in Table 2 and Figure 1.

Assessment of pH measurements taken 20 minutes after acidification of the medium at 24 hours, 48 hours and 7 days of restoration

The difference among the restoration groups in pH measurements obtained 20 minutes after acidification of the medium was significant at 24 hours, 48 hours, and 7 days. The samples prepared as a single, edentulous block displayed significantly lower pH values compared to O, MO and MOD groups at 24 hours, 48 hours and 7 days. For the restored teeth, a significant difference was seen in pH values between O and MO groups and between O and MOD groups at 24 hours. The highest pH value was observed in the MOD restorations at the end of 24 hours. The 20-min data are shown in Table 3 and Figure 2.

Assessment of pH measurements taken 30 minutes after acidification of the medium at 24 hours, 48 hours and 7 days of restoration

The difference in pH measurements was significant among the restoration groups at 30 minutes after acidification of the medium at 24 hours, 48 hours, and 7 days. The samples prepared as a single, edentulous block showed significantly lower pH values compared to O, MO and MOD restoration groups at 24 hours, 48 hours, and 7 days. For the restored teeth, a significant difference was seen in pH values between O and MO groups and between O and MOD groups at 24 hours, and between O and MOD groups at 48 hours. The highest pH value was observed in the MOD restorations at the end of 24 hours. The 30-min data are shown in Table 4 and Figure 3.

Table 2. Assessment of pH measurements taken 10 minutes after acidification of the medium at 24 hours, 48 hours, and 7 days of restoration.

	GRUP	N	Mean	SD	Test	P	Difference
24 hours	BLOCK[1]	10	4.35	0.06	F=6.924	0.001*	1-3
	O[2]	10	4.42	0.08			1-4
	MO[3]	10	4.46	0.03			
	MOD[4]	10	4.46	0.04			
48 hours	BLOCK[1]	10	4.23	0.05	F=19.209	0.001*	1-2
	O[2]	10	4.41	0.07			1-3
	MO[3]	10	4.32	0.03			1-4
	MOD[4]	10	4.33	0.03			2-3.2-4
7 days	BLOCK[1]	10	4.29	0.01	KW=25.784	0.001*	1-2
	O[2]	10	4.39	0.05			1-3
	MO[3]	10	4.48	0.10			1-4
	MOD[4]	10	4.41	0.05			2-3

*The different is significant at the 0.05 level (p<0.05), [1234]Each number denotes a different group 1: Block 2:O 3:MO 4:MOD, Differences are shown in the table.

Tablo 3. Assessment of pH measurements taken 20 minutes after acidification of the medium at 24 hours, 48 hours, and 7 days of restoration.

	GRUP	N	Mean	SD	Test	P	Difference
24 hours	BLOCK[1]	10	4.36	0.05	F=21.805	0.001*	1-2
	O[2]	10	4.45	0.06			1-3
	MO[3]	10	4.55	0.04			1-4
	MOD[4]	10	4.58	0.09			2-4.2-3
48 hours	BLOCK[1]	10	4.34	0.07	F=5.861	0.002*	1-2
	O[2]	10	4.41	0.06			1-3
	MO[3]	10	4.44	0.08			1-4
	MOD[4]	10	4.41	0.04			
7 days	BLOCK[1]	10	4.34	0.03	F=11.019	0.001*	1-2
	O[2]	10	4.44	0.07			1-3
	MO[3]	10	4.51	0.08			1-4
	MOD[4]	10	4.45	0.06			

*The different is significant at the 0.05 level (p<0.05), [1234] Each number denotes a different group 1: Block 2:O 3:MO 4:MOD, Differences are shown in the table

Tablo 4. Assessment of pH measurements taken 30 minutes after acidification of the medium at 24 hours, 48 hours, and 7 days of restoration.

	GRUP	N	Mean	SD	Test	P	Difference
24 hours	BLOCK[1]	10	4.35	0.04	F=51.503	0.001*	1-2
	O[2]	10	4.53	0.05			1-3
	MO[3]	10	4.61	0.05			1-4
	MOD[4]	10	4.66	0.07			2-4.2-3
48 hours	BLOCK[1]	10	4.30	0.05	F=19.883	0.001*	1-2
	O[2]	10	4.42	0.06			1-3
	MO[3]	10	4.48	0.06			1-4
	MOD[4]	10	4.51	0.07			2-4
7 days	BLOCK[1]	10	4.39	0.06	F=8.145	0.001*	1-2
	O[2]	10	4.49	0.09			1-3
	MO[3]	10	4.55	0.06			1-4
	MOD[4]	10	4.49	0.09			

*The different is significant at the 0.05 level (p<0.05), [1234] Each number denotes a different group 1: Block 2:O 3:MO 4:MOD, Differences are shown in the table

Tablo 5. Assessment of pH measurements taken 60 minutes after acidification of the medium at 24 hours, 48 hours, and 7 days of restoration.

	GRUP	N	Mean	SD	Test	P	Difference
24 hours	BLOCK[1]	10	4.47	0.06	KW=25.256	0.001*	**1-2**
	O[2]	10	4.65	0.09			**1-3**
	MO[3]	10	4.64	0.04			**1-4**
	MOD[4]	10	4.74	0.05			**2-4.3-4**
48 hours	BLOCK[1]	10	4.29	0.04	F=31.356	0.001*	**1-2**
	O[2]	10	4.54	0.10			**1-3**
	MO[3]	10	4.53	0.07			**1-4**
	MOD[4]	10	4.60	0.08			
7 days	BLOCK[1]	10	4.35	0.04	F=24.671	0.001*	**1-2**
	O[2]	10	4.52	0.05			**1-3**
	MO[3]	10	4.61	0.11			**1-4**
	MOD[4]	10	4.64	0.08			**2-4**

*The different is significant at the 0.05 level (p<0.05), [1234] Each number denotes a different group 1: Block 2:O 3:MO 4:MOD Differences are shown in the table

Table 6. Comparison of mean pH values among the groups at 24 hours.48 hours. and 7 days.

	GRUP	N	Mean	SD	Test	P	Difference
24 hours	BLOCK[1]	10	4.38	0.04	KW=28.503	**0.001***	1-2
	O[2]	10	4.51	0.06			1-3.
	MO[3]	10	4.57	0.03			1-4.2-4
	MOD[4]	10	4.61	0.04			2-3.3-4
48 hours	BLOCK[1]	10	4.28	0.05	F=24.310	**0.001***	1-2
	O[2]	10	4.44	0.07			1-3
	MO[3]	10	4.44	0.03			1-4
	MOD[4]	10	4.46	0.03			
7 days	BLOCK[1]	10	4.36	0.01	KW=15.109	**0.001***	1-2
	O[2]	10	4.48	0.05			1-3
	MO[3]	10	4.55	0.10			1-4
	MOD[4]	10	4.53	0.05			

*The different is significant at the 0.05 level (p<0.05), [1234] Each number denotes a different group 1: Block 2:O 3:MO 4:MOD Differences are shown in the table

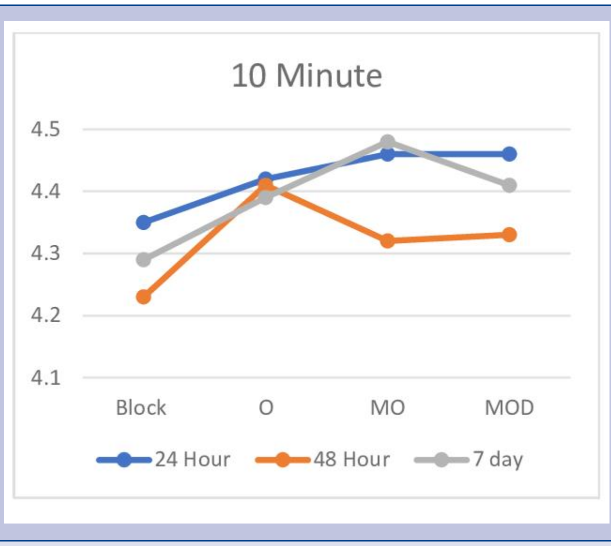

Figure 1. Mean changes in pH value after acidification of the medium (pH=4) and placing samples (24 hours, 48 hours, and 7 days) at 10 minutes

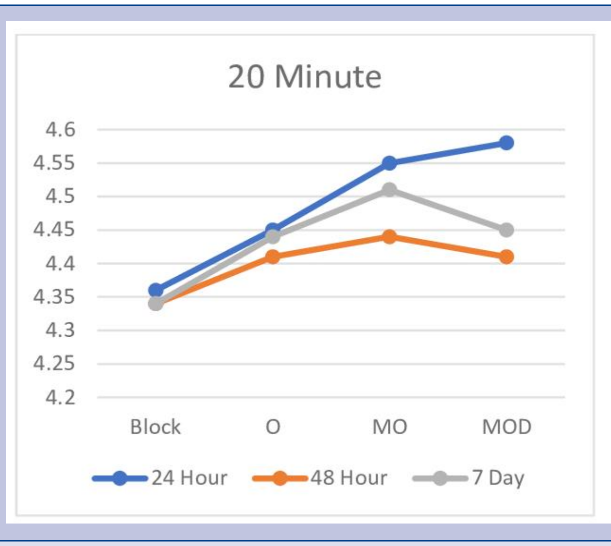

Figure 2. Mean changes in pH value after acidification of the medium (pH=4) and placing samples (24 hours, 48 hours, and 7 days) at 20 minutes.

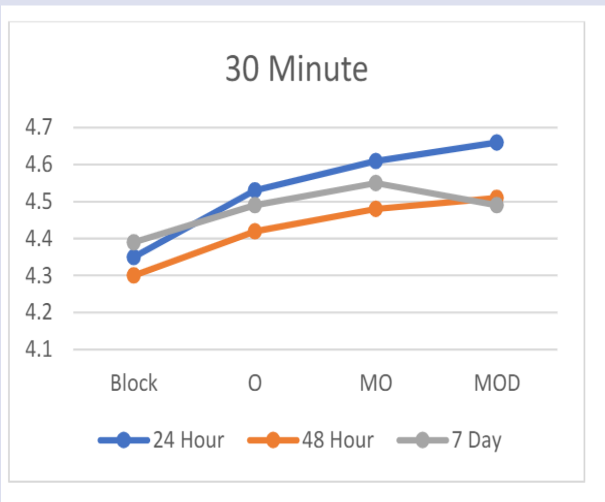

Figure 3. Mean changes in pH value after acidification of the medium (pH = 4) and placing samples (24 hours, 48 hours, and 7 days) at 30 minutes.

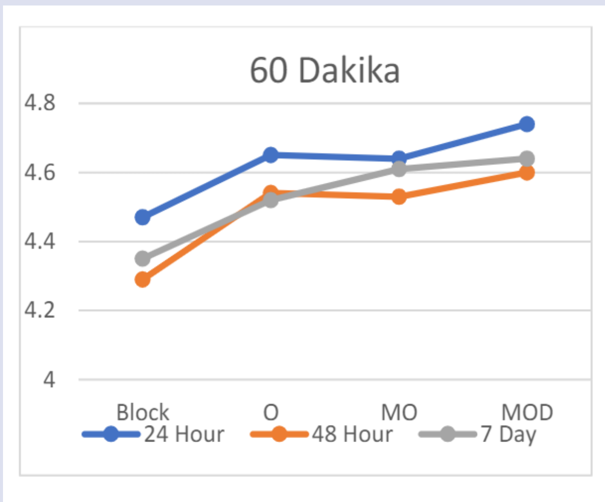

Figure 4. Mean changes in pH value after acidification of the medium (pH = 4) and placing samples (24 hours, 48 hours, and 7 days) at 60 minutes.

Assessment of pH measurements taken 60 minutes after acidification of the medium at 24 hours, 48 hours and 7 days of restoration

The difference among the restoration groups in pH measurements obtained 60 minutes after acidification of the medium was significant at 24 hours, 48 hours, and 7 days. The highest pH values were observed in MOD restorations at all time intervals, and at 24 hours for all groups. The samples prepared as a single, edentulous block exhibited significantly lower pH values compared to restored teeth. Among the restored teeth groups, a significant pH difference was found between O and MOD and between MO and MOD groups at 24 hours, and between O and MOD groups at 7 days. Minimal pH increase was observed at 48 hours. 60-min data are presented in Table 5 and Figure 4.

Mean overall values for 24 hours, 48 hours and 7 days

When the mean measurement values were compared among the groups, the highest pH values were seen at 24 hours and the lowest values at 48 hours. Mean pH values for the individual groups at 24 hours were in the following ranking order: (MOD)> (MO)> (O)>Block and the difference was significant. At 48 hours and 7 days, only samples from the single, edentulous block displayed significantly lower pH values compared to the restored teeth groups. Data are shown in Table 6 and Figure 5.

Figure 5. Plot of mean pH values at 24 hours, 48 hours and 7 days.

Discussion

In restorative dentistry, bioactive glass materials are restorative materials that can elicit a positive response by interacting with the biological environment, release specific ions to the bonding interface to protect dental tissues and induce remineralization, and strengthen bonding through apatite formation.[16, 17]

In in vitro studies, ion release is affected by many intrinsic and extrinsic factors. Intrinsic factors include the composition of the material, powder/liquid ratio, mixing time, temperature, material solubility, surface treatments, and finishing procedures. Extrinsic factors include the characteristics of storage medium (e.g., pH, temperature, ionic characteristics, viscosity), and experimental setting (volume, renewal frequency and mixing of the incubation medium). [15]

The bioactivity of Cention N is achieved using three types of inorganic glass, namely barium aluminosilicate glass, calcium barium fluoroaluminosilicate glass, and alkaline fluorosilicate glass known as alkasite fillers[18]. Its formulation does not contain phosphate. Alkaline glass fillers found in the material can release hydroxyl ions, and neutralize the pH of the environment when it drops below the critical threshold.[19] Ion exchange between Ca^{2+} and H^{+} seems to play a role in conferring Cention N this unique feature. The release of fluoride and calcium ions in high quantities creates a favorable milieu for the remineralization of the tooth enamel. The mixed form of Cention N contains 24.6% of alkaline glass, which accounts for ion release.[18] It has been reported that Cention N can remineralize the underlying dental surface when applied without using an adhesive. This material is indicated for use in temporary restorations, and occlusal, proximal, and cervical restorations of posterior teeth.[20]

While there are many studies on Cention N, its alkalizing potential has been investigated in only a few studies. To the best of our knowledge, none of the previous studies compared alkalizing potential of edentulous restoration blocks versus dental restorations of different sizes as in our current study. When the results of our study were evaluated, a significant difference was observed among the groups in the pH values measured at 24 hours, 72 hours and 7 days following restoration ($p<0.05$). In general, MO and MOD restorations showed higher pH values compared to O restorations and edentulous restoration blocks at all timepoints tested. Therefore, our hypotheses were rejected.

The mean pH values measured at 24 hours were higher than those measured at 48 hours and 7 days (Figure 5). Kasraei *et al*. found greater ion release from Cention N at 24 hours compared to other composite materials and suggested that this might be due to the formation of voids in Cention N while mixing the powder and liquid, and the presence of calcium fluorosilicate alkaline fillers. The authors also argued that these voids cause water sorption, which may increase dissolution of the material and thus increase ion release. Additionally, they suggested that greater ion release may have resulted from increased amount of unpolymerized material due to the prevention of polymerization reactions by the voids.[21] When calcium fluorosilicate alkaline fillers are placed in a moist environment (oral cavity), water sorption occurs, and calcium, aluminum ,and fluoride ions are released. These ions do not take part in the setting reaction. [22]

In one study, Singh et al. examined fluoride release from GCI, RMGCI, and Cention N, and reported that Cention N showed the lowest amount of fluoride release on day 1 but significantly high ion release on days 7 and 14. They suggested that while Cention N lacks an initial burst effect, it constantly releases fluoride ions over the long term. The authors attributed long-term ion release property of Cention N to higher powder/liquid ratio as well as its high content of alkaline glass fillers.[18]

In a study comparing fluoride ion release and pH alterations among 4 different restorative materials fabricated in the form of disc (diameter, 6 mm and height, 2 mm), Kelić et al. reported that Cention N provided the highest ion release and pH changes after 24 hours. They suggested that this was related to its high inorganic filler content.[23] In our study, mean pH values were highest at 24 hours and decreased at 48 hours (Figure 4), suggesting that maximal ion release occurred at 24 hours due to superficial dissolution, followed by slower ion release over time.

In the present study, the samples prepared as a single edentulous block exhibited significantly lower pH values compared to dental restorations. This may be an indication of the alkalizing effect of ions released from the teeth as a result of demineralization.

Lower alkalizing potential and lower release of hydroxyl ions were reported for Cention N in a study comparing Cention N with a resin-modified glass ionomer. Surface modification of Cention N fillers, which rendered them more resistant to dissolution was considered as the most plausible explanation for these findings.[21] In the same study, greater ion release, and higher alkalizing potential of RMGIC were attributed to the presence of poly-HEMA hydrogel phase in its structure, which resulted in further water absorption and greater release of hydroxyl ions. Cention N does not contain HEMA or TEGDMA in its composition, which may cause hydrolytic degradation of bioglass particles.[20,24]

Gupta et al. assessed the release of hydroxyl ions from Cention N and glass ionomer in distilled water and acidic solution and concluded that Cention N was more capable of neutralizing an acidic environment. They also stated that self-cure Cention N had greater alkalizing potential than its light-cure form and RMGI, which could be due to greater solubility and ion release when Cention N is polymerized as self-cure.[25]

In a study by Jingarwar et al. using GIC, RMGIC, and giomer restorative materials, the highest fluoride release was seen at 24 hours with all materials, which was reduced on days 7 and 15. Maximal fluoride release observed at 24 hours, as also seen in our study, was explained by the surface wash-off effect. They suggested that the subsequent decline in fluoride release was probably due to diffusion through cracks and pores. [26]

Our findings showed a marked increase in pH values following acidification of the environment. However, it seems that the pH increase was not great enough to prevent demineralization. As the pH was still below the critical threshold, the demineralization process probably continues clinically, albeit at a slower rate.[18, 27] In our study, the teeth were not evaluated with regard to demineralization and remineralization. Previously, Donly et al. compared demineralization inhibitory effects of Vitremer, Z 100, and Cention N on Class V restorations. They found that the teeth restored with Cention N showed lower demineralization than the teeth restored with Z100, a conventional composite, but higher demineralization than the teeth restored with Vitremer.[28] Kim *et al.* restored bovine teeth with a glass ionomer, RMGIC, and Cention N then examined enamel microhardness at 10 hours after immersion in a demineralization solution (pH adjusted to 4.4 with acetic acid). Also, SEM images were obtained from the enamel surface. The authors found no significant reduction in the microhardness of the teeth restored with Cention N and concluded that Cention N increased the resistance of the dental tissue to demineralization. On post-demineralization SEM images, the enamel not restored with any of these materials showed greater roughness compared to all other groups, and Cention N was found to have greater resistance against demineralization than other restorative materials tested.[29]

Significantly lower pH values were observed for the samples prepared as a single edentulous block in comparison to restored teeth (Figures 1-4). This may indicate the alkalizing effect of ions released from teeth as a result of demineralization. Under oral physiological conditions, it takes about 30 minutes for the saliva to neutralize the acid produced by the biofilm. The amount of saliva in the mouth constantly changes due to swallowing and secretion cycles and depending on the environmental conditions. On average, the normal saliva flow rate is 0.6 ml/min daily.[30] In the current study, the samples were stored in 0.5 ml distilled water at pH 4 and pH readings were obtained at 10-min, 20-min, 30-min and 60-min timepoints following immersion for 24 hours, 48 hours and 7 days. Outside of these time intervals the samples were stored in distilled water at neutral pH 6.8. However, as a limitation of our study, it should be noted that it was not designed to mimic continuous saliva secretion and swallowing to keep the saliva volume constant in the oral environment. Although the alkasite material did not increase the pH of the medium above the critical threshold, it can be suggested that the application of bioactive agents can shorten demineralization time, and have a protective effect on the tooth structure. Due to increased concentrations of calcium, phosphorus and fluoride by alkasite material and its alkalizing potential, the equilibrium can change towards remineralization even in acidic conditions.[31]

Conclusions

The edentulous alkasite blocks exhibited the lowest pH increase at all measurement time intervals. Based on this finding, we think that ions released to the environment due to demineralization of the tooth also have a considerable impact. Although ions released from alkasite material cannot increase the pH above the critical threshold, they can accelerate the process. In vitro studies that mimic intra-oral conditions better are needed to evaluate the alkalizing potential of alkasite material.

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Conflicts of Interest

There is no conflict of interest.

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