Original Article

Comparative evaluation of the antimicrobial activity of an alkasite restorative material with glass ionomer and resin-modified glass ionomer cement

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Abstract

Introduction: Cention N is an alkasite restorative material, containing alkaline fillers. It is assumed that Cention N can neutralize an acidic pH by releasing fluoride, calcium, and hydroxyl ions. This study aimed to compare the antibacterial activity of Cention N with conventional glass ionomer cement (GIC) and resin-modified glass ionomer cement (RMGIC).

Methods: Twenty experimental specimens were prepared from each of the Fuji IX (GIC), Fuji II LC (RMGIC), and Cention N (alkasite) using a cylindrical-shaped mold. The specimens were placed in agar plates at 37°C and inoculated *with S. mutans* (ATCC 25175). After 48 hours, the diameter of growth inhibition zones was recorded for each group at different time intervals including 3, 6, 12, 24, and 48 h. The data were analyzed by one-way ANOVA and Tukey's HSD test with a confidence level of 0.05.

Results: Cention N exhibited significantly higher antimicrobial activity against *S. mutans* at 3, 6, 24, and 48 h as compared to Fuji IX and Fuji II LC (P<0.05).

Conclusions: Cention N could be considered as a suitable alternative for glass ionomers and resin-modified glass ionomers concerning its caries-preventive effects. *(J Dent Mater Tech 2023;12(1): 22-27)*

Keywords: *Alkasite, dental cement, glass ionomer, resin-modified glass ionomer, s. mutans*

Introduction

Dental caries remains a worldwide public health problem affecting 2.4 billion people; 621 million of whom are children (1). Restoring teeth with carious lesions is a routine dental procedure in paediatric dentistry and aims to restore the aesthetics and function of the carious tooth, as well as preventing the recurrence of such lesions (2-6). Fluoride is used as an antimicrobial agent in some restorative materials because preventing recurrent lesions is now an important clinical requirement (7).

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A recent systematic review revealed that the leading cause of restoration failure in paediatric patients, is due to secondary caries (36%) (8). Hence, trials investigating new restorative materials which offer better antibacterial and mechanical properties are interesting.

Conventional glass ionomer cement (GIC) exerts its antimicrobial activity through continuous release of fluoride at the early phase (over 48 h). It is believed that the gradual release of fluoride may provide the caries-preventive effect at the tooth-restoration interface (9).

In recent years, new restorative materials with enhanced properties have been manufactured. An alkasite restorative material is a new filling material, which is considered as a subgroup of resin composites. It benefits from the alkaline (calcium fluoro-silicate glass) filler within its structure, which makes it capable to release acid-neutralizing ions on the surface of the material. Cention N is a basic, resin-based, alkasite (self-curing powder and liquid), and tooth-colored restorative material used for direct restorations and can release fluoride, calcium, and hydroxyl ions (10). It is assumed that Cention N may possess a better antibacterial effect

than other glass ionomer-based restorative materials, as it releases
fluoride and hydroxyl ions after setting. However, the literature contains insufficient information about the caries preventive effects of the alkasite material.
The present study evaluated and compared the antimicrobial activity of the novel alkasite material, Cention N, with the conventional glass ionomer (GIC) and resin-modified glass ionomer (RMGIC) cements.

Materials and methods

The present *in vitro* study was carried out in the Department of Pedodontics and Preventive Dentistry, Sathyabama Dental College in collaboration with the Department of Microbiology, Sathyabama Dental College and Hospital. The study was carried out over two months under the ICMR _STS scheme, 2019. The study protocol was approved by the Institutional Review Board, and the reference number was obtained [Ref:115-IRB-IBSEC/SIST Dated: 19th June 2019].

The tested materials were categorized into three experimental groups as follows: Group 1: Fuji IX (GC Asia Corporation, Tokyo, Japan), group 2: Fuji II LC (GC Asia Corporation, Tokyo, Japan), and group 3: Cention N (Ivoclar-Vivadent Corporation, Asia).

Twenty specimens of each experimental group were prepared using a cylindrical-shaped metal mold, measuring approximately 8 mm in diameter and 5.5 mm in height (Fig. 1). The molds were marked and allocated to three experimental groups. Each specimen was prepared manually according to the manufacturer's instructions. Samples of group 1 were mixed manually according to the manufacturer's instructions and placed in the metal molds; then covered with mylar strips and allowed to set spontaneously (Fig. 2). Samples of group 2 and group 3 were manually mixed and packed into molds, followed by curing for 20 s from top and bottom. Irradiation was performed with a halogen bulb emitting blue light at 470 nm wavelength (Bluephase NM, Ivoclar-Vivadent).

Stock cultures of *Streptococcus mutans* (ATCC 25175) (Himedia Laboratory Pvt. Ltd., Mumbai, India) were maintained at 4°C on a slant of nutrient agar. The inoculums were evenly spread on sterilized Mueller-Hinton Agar (MHA) medium in Petri dishes using a sterile plate spreader.

The disc diffusion method was used to determine the antibacterial activity. The blunt end of a micropipette tip was used to create three 5.5 mm-deep wells. Specimens from the experimental groups were transferred into and completely filled the wells (Fig. 3). The culture plates were kept at 37°C in an incubator for 48 h. A Vernier calliper measured the diameters of the inhibition zone around the specimens in millimetres (Fig. 4). The zone of inhibition was measured as the greatest distance between the two points at the outer limit of the inhibition halo formed around the wells. The zone of inhibition was calculated at time intervals of 3, 6, 12, 24, and 48 h. Three readings were taken for each specimen, and an average of three readings was recorded.

Figure 1. A metal mold used for specimen preparation with 8 mm internal diameter and 5.5 mm height

Figure 2. Prepared and labelled experimental specimens in metal molds

Figure 3. Placement of experimental set specimens in the agar wells

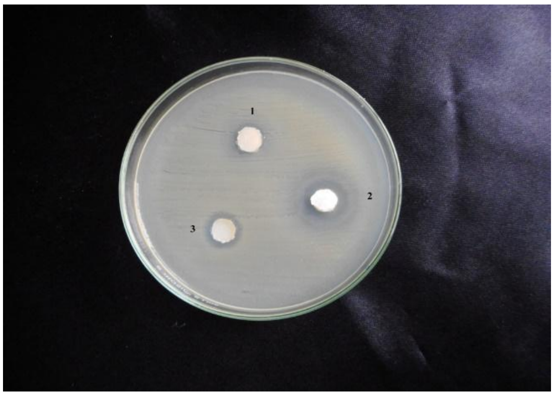

Figure 4. Growth inhibition around the experimental set specimens at 24 h

Statistical analysis

The obtained data were subjected to normality testing using the Shapiro-Wilk test. Since the data were normally distributed, the parametric test of significance was used. The mean and standard deviation (SD) values pertaining to zones of inhibition were calculated at 3, 6, 12, 24, and 48 h. Data were analyzed and tabulated using the SPSS statistical software (IBM, version 20). The values were compared by one-way analysis of variance (ANOVA), and multiple pairwise comparisons were done by Tukey's HSD test. A p-value of <0.05 was considered statistically significant.

Results

The growth inhibition zone around each specimen was calculated from the outer zone and the mean of three values was accounted for each specimen. Table 1 presents the mean values and standard deviations (SD) of the diameter of growth inhibition zones at different time intervals for three different groups. In all experimental groups, it was observed that there was an increase in the mean diameter of growth inhibition zones over 48 h. Figure 5 illustrates the increase in the diameter of growth inhibition zones at different time intervals.

ANOVA revealed a significant difference in the growth inhibition zone among the study groups ($P<0.001$). Pairwise comparisons between groups was made by Tukey's HSD test and the results are presented in Table 2. It was observed that Cention N (Group 3) had a significantly greater antibacterial activity compared to Fuji IX (group 1) and Fuji II LC (group 2) at 3, 6, 24, and 48 h ($P<0.05$; Table 2). At 12 h, there was no statistically significant difference between Cention N (group 3) and Fuji IX (group 1) ($P=0.47$). Fuji II LC (group 2) exerted less antimicrobial activity at all intervals compared to Fuji IX (group 1) and Cention N (group 3), and the difference was statistically significant ($P<0.05$; Table 2).

Table 1. The mean ± standard deviation (SD) of zone of inhibition (mm) at different time intervals in three restorative materials

Group	3 h	6 h	12 h	24 h	48 h
Group 1 (GIC)	2.49 ± 0.93	2.78 ± 0.84	5.96 ± 0.85	11.78 ± 0.55	12.19 ± 0.71
Group 2 (RMGIC)	1.73 ± 0.79	1.96 ± 0.75	4.53 ± 0.55	11.07 ± 0.59	11.37 ± 0.63
Group 3 (Cention N)	3.70 ± 0.78	3.70 ± 0.78	5.60 ± 1.30	13.83 ± 1.17	14.22 ± 1.14
P value	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

*Statistically significant (ANOVA test)

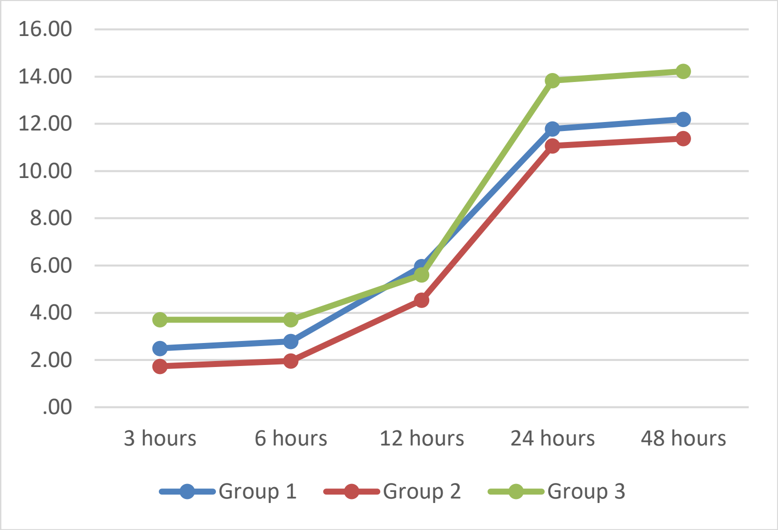

Fig 5. Inter- and intra-group comparison of inhibition zones (mm) at different time intervals in the study groups (group 1: glass ionomer cement, group 2: resin-modified glass ionomer cement, group 3: alkasite restorative material).

Table 2. Pairwise comparisons of inhibition zone diameters between the three groups at different time intervals

Groups	3 h	6 h	12 h	24 h	48 h
1 vs 2	0.016*	0.005*	0.000*	0.02*	0.01*
1 vs 3	0.002*	<0.001*	0.47	<0.001*	<0.001*
2 vs 3	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

*Statistically significant (post-hoc Tukey's test)
Group 1: glass ionomer cement, group 2: resin-modified glass ionomer cement, group 3: alkasite restorative material

Discussion

Dental caries is recognized as a biofilm-dependent dental disease that is aggravated with sugar consumption. The bacterial composition of dental biofilm stays relatively constant even when exposed to minor changes in the oral environment. However, a higher intake of sucrose results in the formation and development of cariogenic biofilms because of the dominance and proliferation of *S. mutans* (11). Therefore, *S. mutans* (ATCC 25175) was used in our investigation to assess antibiotic activity.

Fluoride-releasing glass ionomers can prevent the formation of cariogenic biofilms, such as *S. mutans*, and possess antibacterial properties. Multiple mechanisms, including inhibition of enzymes (enolase, sulfatase, and catalase), play a role in the ability of fluoride to inhibit glycolysis and physiological activity of *S. mutans* biofilm (12, 13). The shortcomings of glass ionomers, such as less satisfactory mechanical characteristics, moisture sensitivity, and surface properties, have led to further quest for novel restorative materials and modified additives (14).

Cention N is a basic, resin-based alkasite self-cured or light-cured restorative material composed of alkaline fillers that are thought to release fluoride and hydroxyl ions when exposed to an acidic pH (10). In the present study, the antimicrobial activity of Cention N was assessed against *S. mutans* and its efficacy was compared with conventional GIC and resin-modified GIC (RMGIC) at various time intervals, similar to that performed by Matalon et al. (15).

The outcomes of this study revealed that Cention N demonstrated greater antibacterial activity at all intervals compared to GIC and RMGIC groups. The only exception was observed at 12 h, when there was no significant difference in antibacterial activity between Cention N and GIC. The enhanced antibacterial activity of Cention N could be attributed to the high fluoride release in the acidic pH, as the acidic pH may cause surface breakdown, thus exposing the matrix and resulting in greater fluoride release (16).

According to Jingarwar et al. (17), the initial burst in fluoride would diminish due to sluggish diffusion through cement pores. In this study, a reduced antibacterial activity was observed in Cention N at 12 h.

This can be attributed to the filler content of Cention N, which results in a less amount of fluoride diffusion. Other factors that may influence the antibacterial results are the observation method and the type of utilized strain (18).

At 12 h, conventional glass ionomer displayed a similar antibacterial activity to Cention N, which could be attributed to the release of fluoride and calcium ions, as previously described by Seppa et al. (19) and Yap et al. (20). The existence of greater filler content in GIC may lead to the initial fluoride burst and explain the comparable antimicrobial activity to Cention N at 12 h (21).

At all intervals, RMGIC displayed some antibacterial activity which was lower than the glass ionomer and Cention N. The antimicrobial effect of RMGIC could be related to the increased release of fluoride ions into the matrix during the setting reaction, as well as the liquid component of RMGIC, which contains hydroxyl-ethyl methacrylate, as suggested by Tarasingh et al. (22).

This was an *in vitro* study, and the results could not be extrapolated to the oral conditions, because dental caries is a biofilm-mediated disease and the efficacy of tested restorative materials against a single bacterial strain may not be clinically valid. Further *in-situ and in vivo* studies are suggested to investigate the antibacterial effects of self-cured and light-cured Cention N and its potential in fluoride release in the oral environment.

Conclusions:

Under the limitations of *in vitro* study, the following conclusions can be drawn:

1. Cention N exhibited significantly greater antimicrobial activity against *S. mutans* compared to GIC and RMGlC at time intervals of 3, 6, 24, and 48 h. This implies that Cention N could be considered as a suitable alternative for glass ionomers and resin-modified glass ionomers concerning its caries-preventive effects.

2. At 12 h, there was no significant difference in antimicrobial activity against *S. mutans* between GIC and Cention N.

Clinical Significance: Cention N could be a potential alternative to conventional GIC and RMGIC restoratives in clinical paediatric dentistry.

Further research: Further in vitro and clinical studies comparing the fluoride release and antimicrobial activity at different time intervals could explore the potential of this novel restorative, which would enhance the usage of Cention N in restorative paediatric dentistry.

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