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# Evaluation of the buffering action of an alkasite restorative material: An *in vitro* study

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**Abstract**
**Introduction and Aim:** Cention N is an "alkasite" restorative material which utilizes an alkaline filler capable of releasing acid-neutralizing ions. These ions can be helpful in buffering the pH of the saliva, thus preventing carious activity. Hence this study was undertaken to investigate the buffering action of the Cention-N restorative material.
**Materials and methods:** Solutions of distilled water with pH values adjusted to approximately 5.5, 6.5 and 7 with lactic acid and sodium hydroxide were prepared. Disk-shaped specimens (2 mm thickness, 7 mm diameter) of Cention-N were made both in self cure and dual cure mode. These discs were exposed to 5 ml of these solutions after which pH of the solutions was measured at room temperature at 1, 5, 10, 15, 20, 30 and 40 minute intervals with a small electrode and pH meter. The data obtained was statistically analyzed using Independent Student t test and Repeated measures ANOVA. The level of significance was set 0.05.
**Results:** At all the tested pH levels and time intervals, there was an increase in the pH values in both self-cure and dual cure groups which was statistically significant. At the critical pH of 5.5, dual cured material performed better than self-cure but at 6.5 and 7 pH both groups performed comparably.
**Conclusion:** Cention N has the ability to buffer the solutions at both acidic and neutral pH values.

**Keywords:** Buffer cention n, dental caries, hydroxide ion, lactic acid

## Introduction
Dental caries is considered a biofilm-sugar dependent disease [1]. The bacteria in the biofilm metabolism the sugar and produce acids causing a pH drop in the biofilm, resulting in demineralization [2]. Possibility of biofilm formation in the interface between the wall of the cavity and the filling material can produce secondary caries in a restored tooth [3]. Other contributing factors for secondary caries include polymerization shrinkage and microleakage, higher plaque retention, and the lack of antibacterial properties [4]. Several studies have shown that this secondary caries is the principal reason for failure of restoration in both permanent and primary dentition [5]. However, if a restorative material has the ability to counteract the acids produced in dental plaque, it may limit the demineralization process responsible for caries progression [6]. Hence it becomes imperative to have a material that has buffering action to neutralize the acids produced, that can in turn reduce the incidence of secondary caries.
The literature on buffering action of restorative materials is limited and mainly focused on glass ionomer cements (GIC). The high fluoride releasing glass ionomers have shown to inhibit demineralization adjacent to restorative margins [5]. However, GIC lacks flexural strength and is unsuitable for stress bearing restorations.
Cention N (Ivoclar Vivadent) is a new alkasite restorative material and a subgroup of the composite material class. It is a self-curing material with additional optional light-curing. It is said to have optimal mechanical properties and can be used for restoration even in stress bearing areas unlike GIC. It utilizes a patented alkaline filler capable of releasing acid-neutralizing hydroxyl ions in addition to fluoride and calcium ions. The hydroxyl ions can neutralise the acids formed by cariogenic bacterial activity. The manufacturer claims the ion release to be pH dependent, in other words, a larger amount of ions are released when the pH-value is low (acidic) than when the pH-value is neutral [7].

This combined effect of hydroxyl, fluoride and calcium ions can potentially reduce the incidence of secondary caries by preventing demineralization and promoting remineralization.
Studies evaluating the buffering action of Cention-N are sparse in literature. Hence in this study, the buffering action of self cured and dual cured Cention-N has been evaluated at neutral (7) and acidic (5.5 and 6.5) pH levels at different time intervals.

## Materials and Methods

### Specimen preparation

30 disk-shaped specimens (2 mm thickness, 7 mm diameter) of Cention-N (Ivoclar Vivadent, Liechtenstein) were prepared according to manufacturer's instructions. These were divided into 2 groups of 15 each.
**Group 1:** Self cure (n=15)
**Group 2:** Dual cure (n=15)

In the self-cure group, the material was allowed to polymerise at room temperature for 4 minutes as per manufacturer's instructions. In the dual cure group, light curing was done with a LED unit for 40 seconds. Both these groups were subdivided into 3 groups 5 samples each according to the initial pH values of the testing solution: 7, 6.5 and 5.5.

### Evaluation of the material's buffering ability in distilled water

The pH of distilled water was adjusted approximately to 5.5, 6.5, 7 by adding lactic acid and sodium hydroxide to it. The disk shaped specimens were exposed to 5 millilitre (ml) of these solutions in small conical flasks. At a time interval of 1, 5, 10, 15, 20, 30 and 40 minutes, an electrode attached to a pH meter (ELICO LI 120 pH Meter) was used to measure the pH of the solutions at room temperature.

### Statistical analysis

Statistical analysis was done using SPSS software Version 22.0 (IBM Corp., Armonk, NY, USA). The mean change in pH levels at different time intervals between self-cure and dual cure group was analysed using Independent Student t test. Repeated measures ANOVA with Greenhouse-Geisser correction was used to compare mean change in pH levels between time intervals in each group. A $p$ value of <0.05 was considered to be significant.

## Results

All the tested samples increased the pH of the lactic acid solution at all tested time intervals. In the group with initial pH 5.5, the mean change in pH at the different time intervals was higher in dual cure than self-cure and this was statistically significant ($p$ value < 0.05). In groups with initial pH 6.5 and 7, this difference was not statistically significant (Table 1). The rise in pH of the solution over a period of 40 minutes was significant ($p$ value < 0.05) at acidic and neutral pH for both self-cure and dual cure material and this was slightly higher in the dual cure group (Table 2).

**Table 1.** Comparison of mean change in pH levels between self and dual cure groups of Cention-N at different time intervals**.**

| | | pH 5.5 | | pH 6.5 | | pH 7 | |
|---|---|---|---|---|---|---|---|
| **Time** | **Group** | **Mean ± SD** | **Mean Difference** | **Mean ± SD** | **Mean Difference** | **Mean ± SD** | **Mean Difference** |
| 1 min | Self | 5.74 ± 0.05 | -0.18* | 6.86 ± 0.27 | 0.06 | 7.22 ± 0.08 | 0.06 |
| | Dual | 5.92 ± 0.13 | | 6.80 ± 0.23 | | 7.16 ± 0.05 | |
| 5 min | Self | 5.86 ± 0.05 | -0.14 | 7.06 ± 0.22 | 0.06 | 7.40 ± 0.12 | 0.08 |
| | Dual | 6.00 ± 0.16 | | 7.00 ± 0.23 | | 7.32 ± 0.13 | |
| 10 min | Self | 5.98 ± 0.13 | -0.22* | 7.02 ± 0.11 | -0.08 | 7.44 ± 0.09 | 0.02 |
| | Dual | 6.20 ± 0.14 | | 7.10 ± 0.23 | | 7.42 ± 0.08 | |
| 15 min | Self | 6.02 ± 0.16 | -0.30* | 7.10 ± 0.14 | -0.12 | 7.48 ± 0.08 | -0.04 |
| | Dual | 6.32 ± 0.13 | | 7.22 ± 0.36 | | 7.52 ± 0.08 | |
| 20 min | Self | 6.08 ± 0.22 | -0.32* | 7.20 ± 0.10 | -0.06 | 7.50 ± 0.10 | -0.02 |
| | Dual | 6.40 ± 0.16 | | 7.26 ± 0.13 | | 7.52 ± 0.11 | |
| 30 min | Self | 6.18 ± 0.30 | -0.40* | 7.26 ± 0.11 | -0.06 | 7.64 ± 0.09 | 0.06 |
| | Dual | 6.58 ± 0.11 | | 7.32 ± 0.08 | | 7.58 ± 0.08 | |
| 40 min | Self | 6.26 ± 0.29 | -0.50* | 7.38 ± 0.08 | -0.10 | 7.70 ± 0.12 | 0.04 |
| | Dual | 6.76 ± 0.05 | | 7.48 ± 0.13 | | 7.66 ± 0.05 | |

SD, standard deviation; min, minute(s).
*Denotes statistical significance in the mean difference between self-cure and dual cure groups with a $p$ value < 0.05 (Independent Student t test)

**Table 2:** Comparison of mean change in pH levels of solutions between different time intervals in self cure and dual cure groups.

| | | Self-Cure | | Dual Cure | |
|---|---|---|---|---|---|
| **PH** | **Time** | **Mean ± SD** | **P-Value** | **Mean ± SD** | **P-Value** |
| **5.5** | 1 min | 5.74 ± 0.05 | 0.03* | 5.92 ±0.13 | <0.001* |
| | 5 min | 5.86 ± 0.05 | | 6.00 ±0.16 | |
| | 10 min | 5.98 ± 0.13 | | 6.20 ±0.14 | |
| | 15 min | 6.02 ± 0.16 | | 6.32 ±0.13 | |
| | 20 min | 6.08 ± 0.22 | | 6.40 ±0.16 | |
| | 30 min | 6.18 ± 0.30 | | 6.58 ±0.11 | |
| | 40 min | 6.26 ± 0.29 | | 6.76 ±0.05 | |
| **6.5** | 1 min | 6.86 ±0.27 | 0.003* | 6.80 ±0.23 | 0.007* |
| | 5 min | 7.06 ±0.22 | | 7.00 ±0.23 | |
| | 10 min | 7.02 ±0.11 | | 7.10 ±0.23 | |
| | 15 min | 7.10 ±0.14 | | 7.22 ±0.36 | |
| | 20 min | 7.20 ±0.10 | | 7.26 ±0.13 | |
| | 30 min | 7.26 ±0.11 | | 7.32 ±0.08 | |
| | 40 min | 7.38 ±0.08 | | 7.48 ±0.13 | |

| | | | | | |
|---|---|---|---|---|---|
| **7** | 1 min | 7.22 ±0.08 | <0.001* | 7.16 ±0.05 | <0.001* |
| | 5 min | 7.40 ±0.12 | | 7.32 ±0.13 | |
| | 10 min | 7.44 ±0.09 | | 7.42 ±0.08 | |
| | 15 min | 7.48 ±0.08 | | 7.52 ±0.08 | |
| | 20 min | 7.50 ±0.10 | | 7.52 ±0.11 | |
| | 30 min | 7.64 ±0.09 | | 7.58 ±0.08 | |
| | 40 min | 7.70 ±0.12 | | 7.66 ±0.05 | |

SD, standard deviation; min, minute(s).

*Denotes the statistical significance in the mean change in pH level between different time intervals with a *p* value <0.05 (Greenhouse-Geisser, Repeated measures ANOVA)

## Discussion

Bacteria produces acids that is responsible for causing demineralization of enamel and progression of caries. The principal acid that is produced is lactic acid (about 85%) and others including acetic acid and propionic acid [8]. Therefore the buffering action has been tested against lactic acid in this study.

The bacterial acid production causes pH fluctuation that governs the loss or gain of calcium and phosphate ions from the teeth. When the pH drops below the critical pH of 6.5 for dentin and 5.5 for enamel, demineralization takes place [2]. Hence the buffering capacity of Cention-N has been evaluated at these critical and neutral pH levels.

The pH drop is usually taken care by the salivary buffer system, namely the bicarbonate (HCO3-), the phosphate, and the protein buffer systems. The HCO3- is believed to be the principal buffer of saliva [9, 10]. Susceptibility to caries was higher with a decrease in buffering capacity of saliva. Fosdick found that an average caries immune patient has a 40% higher buffering capacity of saliva than a caries susceptible individual [11].

Stephan, after series of experiments concluded that caries results from prolonged exposure to a pH below the critical value and that the saliva takes an average of 30 – 60 min to buffer the pH back to normal [12]. The tooth structure is more susceptible to acid attack in this critical period. This study was carried out to evaluate the buffering capacity of Cention-N from 1 to 40 minutes, immediately after pH drop even before the salivary buffer action could take over.

Several restorative materials are also said to have some buffering action *in vitro*. In one study, amalgam exhibited a strong acid-buffering ability due to the release of its corrosion products. Amalgam contains a strong reducing agent like zinc and amphoteric compounds like tin and copper oxides that could react as a base in acidic conditions [13, 14]. However the role of this during a pH drop in oral conditions is not much studied. Glass ionomer cement has also shown buffering capacity. This is mainly attributed to the acid base setting reaction resulting in salt formation and release of ions from the cement [15-17]. Nonetheless, some studies found no buffering action for GIC [18]. Several studies also found loss of material on exposure to acid conditions [16, 19]. This can affect the longevity of the restoration. S-PRG fillers containing cements were also found to have buffering action that might help in caries resistance and prevention [20]. Conventional composites show no buffering ability which, along with lack of antibacterial properties, polymerization shrinkage, and subsequent microleakage, will contribute to the higher susceptibility of composites to secondary caries [4].

Cention N is a new basic, resin-based material that could be an alternative to amalgam and glass ionomer cements. This material is said to have special fillers (calcium fluoro silicate glass) releasing hydroxide (OH-) ions which buffers the acidity and helps prevent demineralization of the tooth. The more the OH- are released, the more H+ will be neutralized, thereby increasing the pH of the solution until the saturation point is reached [21]. And this pH buffering capacity of Cention N has been evaluated in this study.

In this study, all the samples tested increased the pH of the lactic acid solution which was statistically significant suggesting that Cention N has buffering capacity as claimed by the manufacturers. This increase in pH was not only seen in groups with acidic pH (5.5 and 6.5) but also in neutral pH group, although it was marginally higher at acidic pH. This contradicts previous study where no significant increase in pH was observed in neutral pH [22]. Several previous studies on the release of fluoride ions from GIC has shown it to be high in acidic conditions [22, 23]. This may be attributed to the study design as freshly mixed samples were used in the current study. Increase in pH for samples even at neutral pH may be beneficial as even mild increase in pH could be neutralized.

At the critical pH of 5.5, the increase in pH in dual cure group was higher compared to self-cure group and this was statistically significant inferring that dual cure has better buffering action at acidic pH. However at pH 6.5 and 7, there was no statistically significant difference between the self and dual cure groups. At a low pH, dual cure material was able to release more ions than self-cure. Gupta N *et al*. [22] however found self-cure Cention-N to have better buffering action than dual cure. This was attributed to the tightly bound or less hydrophilic matrix due to photo polymerization of alkasite restorative material.

The difference in ion release from self-cure and dual cure restoratives has been debatable. While many studies found an increased ion release from self-cure materials, light curing has increased the ion release in some [24]. Additional light curing had no effect on ion release in other studies [24, 25].

Several factors like the solubility and permeability of resin matrix and filler characteristics affects ion release. The effect of curing on the ion release was found to be product dependent [24]. A study by Ilie N *et al*. [26] found the degree of conversion and micro mechanical properties of self and dual cure Cention-N to be similar 11 minutes after mixing. In this study the materials were tested 4 minutes after mixing as recommended by the manufacturer. This could have had an effect on our results, although the reason for higher buffering action of dual cure material at 5.5 pH is not clear and requires detailed evaluation.

The buffering capacity of restoratives may potentially be advantageous in patients with high caries index, salivary disorders, pediatric patients and those undergoing radiation therapy. The long term sustainability of this buffering action and its effect on preventing secondary caries formation *in vivo* needs to be evaluated in the future studies.

## Conclusion

Under the limitations of the study, it can be said that Cention N has buffering (alkalizing) ability at both acidic and neutral pH values. The dual cured material had a better buffering capacity than self-cure at the critical pH of 5.5.

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