Comparative assessment of fluoride release and recharge through newer fluoride releasing posterior restorative materials: An in vitro study

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Abstract

Aim: This study aimed to assess and compare the fluoride release and recharge capacity of CentionN, Zirconomer and Gc Gold Label 9 Extra.

Methodology: Disk-shaped specimens (n = 12) of CentionN, Zirconomer and Gc Gold Label 9 Extra were prepared according to manufacturer’s instructions. After setting, each specimen was dipped in a plastic tube containing 5ml deionized water and incubated at 37°C ± 2°C. Every 24 h, the samples were placed in fresh 5 ml deionized water. Mean fluoride release (in ppm) from each material, on day 1 and day 6 was calculated using a spectrophotometer. On day 6, the specimens were recharged with 0.2% neutral NaF solution for 2 min and the fluoride release on day 7 was determined.

Results: Cention N released significantly greater amount of fluoride on day 1 and day 6, than zirconomer and Gc Gold Label 9 Extra (P < 0.001). Cention N showed a better recharge capacity than zirconomer and Gc Gold Label 9 Extra (P < 0.001).

Conclusions: Cention N with a higher fluoride release and recharge capacity can be used as a posterior restorative material in patients with high caries risk, thereby inhibiting secondary caries

Keywords: Deionized water; fluoride; recharge; spectrophotometer

INTRODUCTION

Out of the various different causes, secondary caries is still considered as the principal reason for restoration failure, in both deciduous as well as permanent dentition. Fluoride is well documented as an anticariogenic agent. Mechanisms involved in the anticariogenic effect of fluoride, includes, reduction in enamel solubility through the formation of more acid-resistant fluorapatite, remineralization of incipient carious lesions, interference with plaque microorganism, inhibition of microbial growth and metabolism. Antibacterial and cariostatic properties depend on the amount of fluoride released from the material. A constant, long-term release of relatively low concentrations of fluoride has been found to be most effective in caries reduction. A long-term fluoride release helps in maintaining the activity of plaque bacteria at a low level.

Due to the fact that fluoride release from a restorative material decrease over time, the “recharging” of restoratives with fluoride has been advocated to maintain a continuously increased level of fluoride release. Effort has been made to incorporate fluoride into composites and compomers as well, but evidence suggest that their fluoride release is not comparable to conventional GICs.

In the literature, there is lack of evidence regarding the fluoride release and recharge capacity of newer fluoride releasing, noncomposite posterior restoratives. Cention N, Zirconomer Improved and Gold label 9 extra (fuji IX) are...
newer, fluoride releasing, noncomposite, high strength posterior restorative with enhanced material translucency. As claimed by the manufacturer, these materials can release fluoride for 9–12 months.

No study has been conducted in the past to compare the fluoride release and recharge capacity of these newer materials. Hence, the purpose of this study was to compare the fluoride release and recharge capacity of Cention N (Ivoclarvivadent), Zirconomer improved (Shofu) and Gc Gold Label 9 Extra (GC) by Spectrophotometric method.

**METHODOLOGY**

The present *in vitro* study was conducted at Analytical Research & Metallurgical Laboratories Pvt. Ltd, Bengaluru, Karnataka.

**Specimen preparation**

For each test material, 12 disk-shaped specimens, 10 mm in diameter, and 3 mm in thickness were prepared using plastic molds [Figure 1]. The materials were mixed according to manufacturer’s instruction. After mixing the samples were allowed to set. Each sample was then dipped in a plastic tube containing 5 ml deionized water and incubated at 37°C ± 2°C. Every 24 h, the samples were placed in fresh 5 ml deionized water. The samples were analyzed for fluoride release on day 1 and day 6. After the fluoride ion analysis on day 6, Specimens were recharged with 0.2% neutral NaF solution for 2 min. Following recharge, the fluoride release was analyzed on day 7.

Fluoride release (in ppm) was determined with the help of SPADNS spectrophotometric method. Zirconvy-SPADNS reagent was prepared in the laboratory and allowed to react with the fluoride in solution. The relative shift in the absorption spectrum of the new complex were detected and the change in absorbance measured by a UV/Visible spectrophotometer (Thermo scientific) [Figure 2].

**Statistical analysis**

Statistical analysis was performed with the help of Statistical Package for Social Sciences for Windows Version 22.0 Released 2013. Armonk, NY, USA: IBM Corp. Descriptive analysis includes expression of fluoride release (in Ppm) in terms of mean and standard deviation. One-way ANOVA test followed by Tukey’s HSD *post hoc* The analysis was used to compare the mean fluoride release (in Ppm) between the three groups at different time intervals The level of statistical significance was set at $P < 0.001$.

**RESULTS**

On day 1, Cention N released the maximum amount of fluoride (mean = 14.33 ppm), followed by gold label 9 extra (mean = 4.74 ppm) and Zirconomer (1.83 ppm). There was statistically significant difference in the fluoride release between the three materials on day 1, i.e., (Cention N vs. Gold label 9 extra), (Cention N vs. Zirconomer) and (Zirconomer vs gold label 9 extra). For all the three materials, there was a rapid decline in fluoride release by day 6. On day 6, fluoride release of Cention N was significantly greater than that of gold label 9 extra and Zirconomer. However, there was no significant difference between Gold label 9 extra and zirconomer. Following recharge, there was an increase in the fluoride release for all the three materials, of which Cention N showed a better recharge property followed by Zirconomer. There was no significant difference between Gold label 9 extra and zirconomer. Following recharge, there was an increase in the fluoride release for all the three materials, of which Cention N showed a better recharge property followed by Zirconomer. There was no significant difference between the recharge ability of gold label 9 extra and zirconomer. Table 1 shows the comparison of mean amount of fluoride release (in ppm) between the three materials at different time intervals. Graph 1 shows the fluoride release pattern of the tested materials over subsequent days.

**DISCUSSION**

SPADNS spectrophotometric method of fluoride determination relies on the fact that when fluoride
Table 1: Comparison of mean amount of fluoride release (ppm) between three materials at different time intervals using one-way ANOVA test followed by Tukey's honestly significant difference post hoc analysis

| Time  | Group      | n  | Mean   | SD  | Minimum | Maximum | P*   | Significant difference | P* |
|-------|------------|----|--------|-----|---------|---------|------|------------------------|----|
| Day 1 | Cention N  | 12 | 14.33  | 1.81| 12.1    | 18.4    | <0.001* | C versus Z             | <0.001* |
|       | Zirconomer | 12 | 1.83   | 0.58| 0.5     | 2.6     | -     | C versus G             | <0.001* |
|       | GC Gold 9  | 12 | 4.74   | 1.46| 2.3     | 6.4     | -     | Z versus G             | <0.001* |
| Day 6 | Cention N  | 12 | 7.09   | 1.42| 4.6     | 9.5     | <0.001* | C versus Z             | <0.001* |
|       | Zirconomer | 12 | 0.72   | 0.28| 0       | 1.1     | -     | C versus G             | <0.001* |
|       | GC Gold 9  | 12 | 0.97   | 0.18| 0.7     | 1.3     | -     | Z versus G             | 0.79  |
| Day 7 | Cention N  | 12 | 1.67   | 0.20| 1.5     | 2.2     | -     | C versus Z             | <0.001* |
|       | Zirconomer | 12 | 1.75   | 0.32| 1.4     | 2.4     | -     | Z versus G             | 0.95  |

*a denotes P-Value of ANOVA test, *b denotes P-Value of Tukey's Post hoc analysis and *c denotes statistically significant, Note: C – Cention N, Z – Zirconomer, G – GC Gold Label
9 Extra. SD: Standard deviation

Graph 1: Fluoride release pattern of the test materials

Reacts with certain zirconium dyes, a colorless complex anion and a dye are formed. The complex, which is proportional to the fluoride concentration, tends to bleach the dye which therefore becomes progressively lighter as the fluoride concentration increases. In the case of the fluoride ion reaction with Zr-SPADNS (sodium 2-(parasulphophenylazo)-1,8-dihydroxy-3,6-naphthalene disulphonate), the change in absorbance of the resulting colored complex was measured in a spectrophotometer at 570 nm and quantification of fluoride release was done.

The content of fluoride in restorative materials should, however, be as high as possible without adverse effects on physical and mechanical properties. An initial burst of fluoride is beneficial, as it aids in remineralization and at the same time decreases the viability of remaining bacteria. Different restorative materials have different matrix and setting mechanism. This difference influences the fluoride release pattern as well as the fluoride uptake characteristics of these materials. Fluoride release is also influenced by experimental factors such as storage media, frequency of change of the storage solution, composition and pH-value of saliva, plaque, and pellicle formation.

Previous studies estimated the quantity of fluoride released into deionized water, artificial saliva, or acidic solutions. However, kinetic findings demonstrated that the patterns of fluoride release from conventional and resin-modified glass ionomers as well as compomeres and composites in different storage media were similar. In the present study, the storage medium used was deionized water, and the storage medium was changed every 24 h. In vitro studies have shown that fluoride release is dependent on exposed surface area and not on sample weight. In the present study, specimens were standardized and had equivalent surface area.

On day 1, Cention N released significantly more fluoride than gold label 9 extra and zirconomer improved. This initial high release of fluoride from Cention N may be attributed to the advanced filler technology used in this material. Out of the four different types of fillers present in the composition of Cention N, three are fluoride enriched. The presence of fluoride containing fillers in Cention N such as Ytterbium trifluoride, Calcium barium aluminum fluorosilicate glass, and Calcium fluorosilicate (alkaline) glass renders it effective in releasing high amount of fluoride. In the mixed state, Cention N contains 78.4% wt. inorganic filler. The alkaline glass accounts for 24.6% in weight of the final material and this may be the reason for the substantial release of fluoride (F-) ions. Furthermore, the high level of fluoride release for all the materials on the first day may be caused by the initial superficial rinsing effect.

In the present study, gold label 9 extra released more fluoride than zirconomer. This may be due to the difference in the chemical and physical characteristics of these materials. The reason for zirconomer improved releasing the least amount of fluoride may be because of increase in zirconia fillers and reduction in the amount of fluoroxideglass in the powder.

Zirconomer improved and gold label 9 extra showed a rapid decline in fluoride release over subsequent days. This finding is in accordance with the result of previous studies. This may be explained by the fact that initially a burst of fluoride is released from the glass particles as they dissolve in polyalkenoic acid during the setting.
reaction, a phenomenon known as the “burst effect.” Later, fluoride release becomes slower and is because of the gradual and sustained diffusion of ions through the bulk cement.\textsuperscript{17,18} Karantakis \textit{et al.} evaluated that the highest fluoride dissolution occurred especially during the first 4 h after mixing amounting to 1.6–1.8 g/mm\textsuperscript{2}. Bell \textit{et al.}, in a study found that the concentration of fluoride released from glass ionomer cement specimens (1.5 mm thick and 6 mm in diameter) into artificial saliva within 10 min after immersion amounted to 1 ppm and that the cumulative total fluoride in the first 24 h was nearly 15 ppm.\textsuperscript{14}

The recharge agent used in this study was 0.2\% NaF which is commonly present in mouthwashes and toothpastes. Since toothpaste and mouthwashes can be used on regular basis they can serve as a potent recharging agent to prevent secondary caries. Following recharge, there was an increase in fluoride release from all the materials. In the present study, Cention N showed a better recharge property, followed by Zircionomer improved. The recharge ability of a material depends on various factors such as permeability of the material, composition, and surface energy.\textsuperscript{7,8} However, permeability seems to be the most important factor influencing fluoride recharge.

There are certain limitations to this study. As mentioned earlier, fluoride release from restorative materials is influenced by composition and pH-value of saliva, plaque, and pellicle formation. Therefore, the findings of this \textit{in vitro} study cannot be directly extrapolated to clinical scenario. Furthermore, due to the nonavailability of ion selective electrodes, a spectrophotometric method of fluoride estimation was used in the present study. Ion selective electrode method is a comparatively new and more accurate method for fluoride estimation and hence the use of this method is justified. However, previous comparative studies suggest that the results obtained by SPADNS spectrophotometric method are similar and comparable to the ion selective electrode method. Furthermore, this study was carried out for a shorter duration of time. Therefore, a long term study on the fluoride release of these materials is required. These limitations should be considered in future studies.

**CONCLUSIONS**

Different materials released variable amounts of fluoride with different fluoride release patterns. All the materials had the ability for recharge, of which Cention N showed a better result. Cention N with a higher fluoride release and recharge capacity can be used as a posterior restorative material in patients with high caries risk, thereby inhibiting secondary caries.

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Nil.

**Conflicts of interest**

There are no conflicts of interest.

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