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# Analysis of Fluoride Uptake and Release from Esthetic Restorative Materials Used Together with Fluoride-Containing Oral Hygiene Products

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**ABSTRACT**
**Background:** Fluoride, one of the most effective caries-prevention agents, tilts the balance toward health. Fluoride is used for cavity prevention and treatment. Fluoride's demineralization, remineralization, pellicle and plaque prevention, and microbial growth and metabolism inhibition make it anticariogenic.
**Materials and Methods:** Ninety standardized discs of the studied materials were fabricated with dimension of (8mm diameter and 2mm thickness) from cylindrical brass moulds suspended in 8ml polyethylene vial. The amount of fluoride released from the materials was tracked for 30 days, with measurements taken on days 1, 2, 7, 14, and 30. The specimens were separated into three groups at the 30-day mark. The control group's specimens were kept in a container of deionized water. The remaining two sets of specimens were subjected to fluoride-containing oral hygiene products (toothpaste and fluoridated mouthwash). The concentration of fluoride was determined 32 days, 39 days, 46 days, and 53 days after refluoridation.
**Results:** The findings showed that all three fluoride-containing dental materials emitted fluoride, but that each material did so in a different way since it was made up of different parts. The most fluoride was emitted by Fuji IX GP, followed by Ketac nano and Gradia direct X. All of the materials were charged and kept releasing after being subjected to fluoridated toothpaste and mouthwash. All of the materials produced more fluoride after being refluoridated, but GICs released the most.
**Conclusion:** Thus, all three fluoride-containing dental materials produced fluoride in distinct ways owing to their chemical compositions. Possibly. Fluoridated toothpaste and mouthwash activated and released fluoride.
**Keywords:** Fluoride release, Fluoride rechargeability, composite resins, Mouthrinses.

## INTRODUCTION

Fluoride, which is one of the most efficient preventative remineralizing agents available, tips the caries balances in favor of health. Both preventative and restorative applications of fluoride are utilized for the purpose of cavity prevention [(1)]. The ability of fluoride to limit demineralization, increase remineralization, prevent pellicle and plaque formation, and restrict microbial growth and metabolism is what gives fluoride its anticariogenic characteristics [(2)].

Following the completion of a repair, the quantity of fluoride that is released from glass ionomers and fluoride-releasing composites progressively diminishes. It has been hypothesized that the capacity to recharge fluoride via the use of a fluoride gel, fluoride dentifrice, or fluoride mouthwash is more essential than fluoride release on its own [(3)].

Fluoride may become accessible to the surface of a tooth if a nearby restorative material releases fluoride into the oral environment. Standard glass ionomer cements (GICs), resin-modified GICs, polyacid-modified composite (compomers), composites, and amalgams are all examples of dental restoratives that include fluoride. GIC containing nanofilled resin has only lately been available on the market [(4)].

After being subjected to fluoride-containing topical treatments, the purpose of this research was to evaluate the fluoride-release concentrations of three distinct fluoride-releasing esthetic restorative materials.

## MATERIALS AND METHODS

### Preparation of specimens

Using a digital venire caliper (Japan original mitutoyo digital of vernier caliper), cylindrical brass molds were used to make 90 identical 8-mm-diameters, 2-mm-thick discs of the research materials [(5)].

The mold was made by attaching a piece of mylar matrix to a glass slide. After that, the medicinal substance was combined per manufacturer's directions. If using Ketac N, the paste was dispensed onto the mixing pad and it was mixed for 20 seconds with the plastic cements spatula until the color was uniform [(6)]. If using Gradia Direct X, the required amount of composite restorative material was dispensed from the syringe onto the mixing pad and transferred it into the mold. To assure polymerization, Ketac nano GIC and

Gradia X composite samples were light-cured from above and below for 20 seconds. A 1-mm glass slide between the cover glass and the specimen regulated the distance between the curing light and the specimen [(7)].

After 10 minutes between the mylar-laced glass slides, the Fuji IX GP discs were gently removed from the mold [(6)]. Each sample was contained in a polyethylene test tube that contained 8 milliliters of deionized water. Throughout the course of the experiment, each of the samples was kept in a controlled environment chamber that had a temperature of 37±0.5ºC and a relative humidity of 100%. The concentration of fluoride ions was determined with the



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aid of an ion analyzer and a fluoride ion electrode. The concentrations of fluoride in the six reference solutions were 0.20, 1.00, 2.00, 10.00, 20.00, and 100 ppm F, respectively. At the conclusion of each stage of the incubation process, the concentration of fluoride ions was measured using TISAB II, which was added to the test tubes. Following a five-second period during which a magnetic combination was combined with a fluoride sample in TISAB buffer, we next obtained a reading by inserting the fluoride electrode straight into the sample (Figure 1). A thorough cleaning was performed on the membrane of the electrode [(10)].

In the first part of the study the quantities of released fluorides was measured in the following time periods :1$^{st}$ , 2$^{nd}$ , 7$^{th}$ , 14$^{th}$ and 30$^{th}$ days **[(10)]** .In the second part of the study , and after 30 days of initial fluoride release measurement ,the 30 disc samples of each material with be divided into three groups .

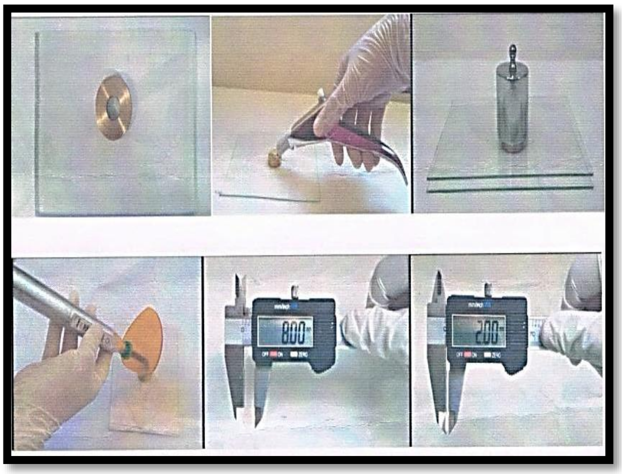

Fig.1: Fluoride concentration measurement using ion-selective electrode

First, there was a group that serves as a "control" and was given absolutely nothing. Those who were allocated to Group 2 were given fluoride mouthwash (Sensodyne mouthwash), while those who were assigned to Group 3 were given fluoride toothpaste (fluor kin toothpaste). The samples from the control group were stored in deionized water throughout the process. The fluoridated mouthwash and toothpaste were used to treat the samples in the other two groups for a period of three weeks. The water was refluoridated once per week for the first two weeks after the first treatment. During the third week, it was carried out each day for a total of four minutes, which was the same as having two sessions of two minutes each. An ion-selective electrode and a digital pH meter were used in order to carry out the analysis and recording of the fluoride readings that were taken at the 32$^{nd}$, 39$^{th}$, and 53$^{rd}$ positions of the refilled specimens.

***Statistical analysis***

SPSS 20. Software (SPSS, Inc., Chicago, IL, USA) was used to analyze continuous variables, the mean and standard error was calculated, and expressed as the mean ± standard error. The statistical analysis was performed using the student's one-way analysis of variance (ANOVA) test. $P \leq 0.05$ was measured to indicate a statistically significant difference.

## RESULTS

In the first portion of the study, all materials released fluoride in the necessary time intervals. The fluoride release from Fuji IX GP showed a "burst effect," with the highest levels appearing in the first 24 hours, dropping abruptly by day two, stabilizing and then decreasing to a low -level long-term release by day seven and fourteen, with even lower levels being reached on day thirty. When compared to fuji IX GP, ketac nano released less fluoride on the first day, but it did so consistently and at a constant level for 30 days. Gradia X composite resin, on the other hand, did not exhibit a significant initial high burst of fluoride ion release, but it did maintain a low and relatively constant level of release over 30 days, but the release was sizable.

The three sets of restorative materials' mean fluoride ions measurements varied from one another in a statistically very significant way (P value <0.001). The cumulative fluoride release data (means and standard deviations) of restorative materials throughout the 30 days prior to solution treatment are shown in Table 1.

**Table (1):** Comparison between mean values and standard deviation of fluoride ions measurement of three studied groups at different studied periods

| Periods of measurement (days) | Number of samples | G1:Fuji IX GP Mean | G2:Ketac Nano Mean ±S.D | G3:Gradia X Mean ±S.D | P-values |
|---|---|---|---|---|---|
| 1st day | 30 | 94.097±0.698 | 64.819±0.342 | 25.100±0.197 | <0.001 |
| 2nd day | 30 | 58.828±0.303 | 46.317±0.474 | 17.396±0.381 | <0.001 |
| 7th day | 30 | 45.895±0.340 | 33.026±0.293 | 9.008±0.057 | <0.001 |
| 14th day | 30 | 32.350±0.573 | 21.774±0.589 | 4.499±0.216 | <0.001 |
| 30th day | 30 | 18.186±0.748 | 10.711±0.852 | 1.633±0.415 | <0.001 |

The use of fluoridated dental care products such as toothpaste and mouthwash led to a significant increase in the fluoride ion release from all substrates. On the first day, the rate of refluorescence was greatest for all of the materials, but it quickly began to decrease. The body was refueled much more by toothpaste than by normal mouthwash. The findings of the present research, on the other hand, indicate that the impacts of revitalization are just temporary. At day 53, when daily refluoridation was administered for the third week, the rate of fluoride ion release significantly increased for all materials; as a result, numerous fluoride injections from the outside were necessary in order to sustain high fluoride release. Following the application of solution treatment, the mean values and standard deviations of the cumulative fluoride release from restorative materials are shown in Table (2).

**Table (2):** Mean and standard deviation (SD) of fluoride release from the three restorative materials studied with different treatments

| Periods of measurement (days) | Treatment | G1:Fuji IX GP Mean ±S.D | Ketac nano Mean ±S.D | Gradia X Mean ±S.D |
|---|---|---|---|---|
| 32th day | Control | 16.731±0.129 | 8.746±0.017 | 1.064±0.015 |
| | Mouth wash | 26.738±0.016 | 20.473±0.033 | 1.567±0.024 |
| | Mouth wash | 36.654±0.016 | 26.768±0.027 | 4.160±0.021 |
| 39th day | Control | 10.829±0.015 | 6.112±0.020 | 0.790±0.073 |
| | Mouth wash | 9.596±0.020 | 8.737±0.022 | 0.880±0.091 |
| | Mouth wash | 16.858±0.013 | 10.857±0.014 | 1.268±0.013 |
| 46th day | Control | 7.829±0.015 | 4.112±0.020 | 0.350±0.108 |
| | Mouth wash | 8.148±0.024 | 6.737±0.022 | 0.420±0.078 |
| | Mouth wash | 14.858±0.013 | 9.357±0.014 | 0350±0.108 |
| 53rd day | Control | 4.731±0.129 | 2.206±0.195 | 0.120±0.042 |
| | Mouth wash | 22.738±0.016 | 16.473±0.033 | 0.567±0.024 |
| | Mouth wash | 32.654±0.016 | 22.768±0.027 | 1.860±0.021 |

## DISCUSSION

### Fluoride release before treatment

Fuji IX GP released the highest concentration of fluoride ions on the first day after being immersed in deionized water [11]. Fuji IX GP was tested. Who was the first to show that the water-based restorative material Fuji IX GP cement mixes by way of an acid-base reaction, therefore leaching Ca2C, A13C, and FK ions from a polysalt matrix.

The ensuing high release and fast decline of fluoride from Fuji IX GP is most likely attributable to the first burst impact of fluoride that was released from glass particles. Fluoride release from Fuji IX GP fell promptly on day two, steadied, and then steadily reduced to a low level of long-term release on days seven and fourteen after day one. Day one was the beginning of the experiment. On day thirty, levels continued their downward trend, which is in line with what [10] discovered. In this investigation, Ketac nano revealed a somewhat different fluoride release pattern in comparison to Fuji IX GP. This difference had an effect on the cumulative fluoride release profile, particularly on day one. On the first day, the traditional glass ionomer cement used by Fuji IX GP released a greater amount of fluoride than ketac nano. This conclusion is consistent with the findings of [11-12] who established that the poor solubility of the drug might explain these phenomena. Scanning electron microscopy was used to determine that the surface morphology of Ketac nano does not include any holes, fractures, or microscopic pores when the material was subjected to immersion in water.

During each and every period and hour that was examined, the Gradia Direct X composite produced lower fluoride emissions compared to both the Fuji IX GP and the Ketac nano. Within a span of thirty days, the vast majority of the fluoride ion was expelled within a span of one week, after which it stabilized without suffering from a fast rise or fall in concentration; the composite resin setting is to blame for the minimal fluoride release shown by Gradia Direct X. One possible explanation for the restricted distribution is the lack of fluoride fillers.

### Fluoride release after recharging

It was discovered that each of the three materials exhibited a substantially different level of fluoride recharge, which is defined as the difference in fluoride release between the control group and the treated group. After being subjected to fluoridated toothpaste, all of the materials produced a greater quantity of fluoride ions than they normally would have. Fuji IX GP and Ketac nano, on the other hand, emitted a greater quantity than the low-emitting Gradia Direct X composite resin. Gradia X virtually completely lost its visibility after being subjected to fluoridated mouthwash, but Fuji IX GP and Ketac nano emitted a much greater quantity of fluoride ions.

Immediately after the re-flooding procedure, the rate of production of all materials was at its highest point; however, this rate gradually fell over the course of the subsequent days. The body was refueled much more by toothpaste than by normal mouthwash. However, the recent study demonstrates that the benefits of recharging only last for a limited period of time. At day 53, when daily reflouridation was delivered for the third week, the rate of fluoride ion release significantly increased for all materials. Because of this, frequent fluoride injections from the outside were necessary in order to sustain high fluoride release. Initial fluoride release from freshly mixed material is always lower for any given degree of refluoridation [13].

## CONCLUSION

Because of this, it is possible to draw the conclusion that all three fluoride-containing dental materials that were tested produced fluoride, albeit in different ways that may be attributed to the distinctive chemical compositions of each of the materials. All of the materials were reactivated and continued to release fluoride into the environment after being exposed to fluoridated dental paste and fluoridated mouthwash.

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