



Fluoride Release and Recharge of a Glass Ionomer Restoration after Acidulated Phosphate Fluoride Gel Application at Different Times. (An In-Vitro Study).

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ABSTRACT

Background: GIC is an effective material in releasing and recharging fluoride over a long period of time .The application of fluoride-containing APF gel can significantly enhance the fluoride release and recharge properties of GIC. These additional treatments provide an extra of fluoride, contributing to the long-term protection and strengthening of teeth.

Purpose: to investigate the fluoride release and recharge properties of a tooth colored restoration (glass ionomer) over different time periods after the application of APF gel.

Methods: 36 specimens were prepared and divided into three groups(24hr. one week, one month), each group divided into two subgroups based on time of APF gel application. Fluoride release was measured at 24 hours, one week, and one month, while fluoride recharge was evaluated after the application APF gel. Results: There was a no significant difference in the release of fluoride from the GIC at 24hr and one week . but there was highly statistical significant differences of fluoride release from (GIC) in one month . The highest mean value of fluoride release was in (24hr), and the least mean value of fluoride release was in (one month). While after fluoride recharge there was highly statistical significant differences (higher fluoride release mean values).

Conclusion: The fluoride release from a tooth colored restoration (glass ionomer) after 24 hr was higher than after one week and after one month,The recharge ability of the restorative material(GIC) after fluoride gel application for (4min) was higher than (2min),Increasing the time that the GIC come in contact with the recharging material resulted in great up take of fluoride compared with the short duration that the F come in contact with GIC.

Keywords:Fluoride ;Release ;Recharge ; Glass Ionomer Restoration (GIC)

I. INTRODUCTION

Dental caries is a prevalent non-communicable disease with a multifactorial a etiology. Studies shows that it can be prevented and reversed in it's early stages.¹Prevention is important to intercept and prevent dental caries and to avoid relapses by modifying pathological factors and protective factors.² Fluoride has a long-term relationship with dental caries and preventive dentistry, there is a strong link between fluoride and carious activity.³ Insufficient exposure to fluoride is a causative factor to develop caries in addition to dietary habits, bacteria, low salivary flow and bad oral hygiene, the anti-cariogenic property of fluoride is related to the inhibition the metabolism of bacteria and growth, prevention of demineralization and acceleration of the re-mineralization process .For that ,the fluoride ion release and recharging capability is an important property of restorative materials.⁴

One of the fluoride releasing materials used for treatment of caries is glass ionomer cement (GIC), it is an appropriate restorable materials that is suitable for restoring primary teeth, the purpose of the current study is to determine the amount of released fluoride from the restoration which is beneficial in inhibiting secondary marginal caries and provide additional effect for protection during fluoride release.GIC is a medical product used as a powder containing fluoride ion,aluminum oxide and silicate, when combined with a mild acidic liquid, can be used as a tooth-coloured restoration⁵. APF gelis the most popular and worldwide used material in pediatric patients to deliver the benefit of fluoride to children, APF gel 1.23% is the most widely used fluoride agent due to its stability and commercial availability, Regular use of fluoride gel have a beneficial effect only for persons at high caries risk, especially who do not live in areas with fluoridated water or who do not brush their teeth with fluoride toothpaste.⁶



In Iraq limited studies have addressed the release ability of restorative materials used in treatment of especially pediatric patients. The goal of this research was to determine how much fluoride was released from GIC and to determine the fluoride ion recharging characteristics of the material after (APF gel) applications at different time.

AIMS OF THE STUDY

- 1- To determine the fluoride release from a tooth colored restoration (glass ionomer) after 24 hours , after one week and after one month .
- 2- To determine the recharge ability of the restorative material after APF gel application at different durations (1 min -4 min).

II. MATERIALS AND METHODS

The current experimental in-vitro study was carried out in 36 specimens that were fabricated and randomly assigned to the groups of study in April 2023 in the central lab of college of Agriculture and Forestry, University of Mosul.

GROUPING OF THE SAMPLES:

The total sample was composed of 36 specimens , divided in to 3 groups.⁷

Group 1: (12 specimens were fabricated) after 24hr. Check fluoride release from GIC, then recharge GIC with APF gel (6 specimens for 1 min and 6 specimens for 4 min).

Group 2 : (12 specimens were fabricated) after 1 week. Check fluoride release from GIC , then recharge GIC with APF gel (6 specimens for 1 min and 6 specimens for 4 min).

Group 3 : (12 specimens were fabricated) after 1 month. Check fluoride release from GIC, then recharge GIC with APF gel (6 specimens for 1 min and 6 specimens for 4 min).

SPECIMENS PREPARATION:

12 disk specimens for each group were prepared, the dimension of all the specimens were 2mm in height and 5mm diameter.⁸ The weight of each specimen was 0.1g as it was checked by balance. Specimens were prepared from the custom-made polyethylen mold (diameter of 5mm, depth of 2mm), filled with glass ionomer restoration (Medifil, Promedica, Germany) (powder/liquid ratio 1:1, mixing time 30-40 seconds according to the manufacturer instruction mixing was done on paper mixing pad) and glass microscopic slide was placed on the two surface of the specimen, pressure was applied by mass (50gm) to extrude excess material, and allowed to set inside the mold for 6min through chemical

curing.⁹ Specimens were taken out of the mold, and transferred into polyethylene containers containing 5ml of deionized water at 37°C. Fluoride release was checked using fluoride ion-selective electrode (EUTECH, Instruments, Singapore) and all data were recorded in ppm at time intervals of 1 day, week and month.¹⁰ For each group The specimens were recharged with APF gel (Germiphene Corporation, Canada) for duration of either (1min and 4min). the fluoride recharge was checked also by fluoride ion-selective electrode, and all data recorded in ppm.

METHOD OF MEASURING FLUORIDE RELEASE FROM GIC AND FLUORIDE RECHARGE APF GEL AT DIFFERENT DURATIONS

The group was subdivided in to sub group that each contains (6specimens) according to experts instructions the head of fluoride ion selective electrode was cleaned with sand paper first, then wash it with distilled water and dried with tissue paper, then measuring the concentration of fluoride in distilled water by putting the head of electrode in container containing distilled water, followed by measuring the standard concentration of fluoride in the same manner, the amount of fluoride release from each specimens after 24hr was measured, the head of electrode was washed with distilled water after each reading and dried, when finished the reading of each sub group (6 specimens) the head of electrode was cleaned with sand paper, washed and dried. Fluoride release was calculated by millivolt. after checking the release of all specimens, recharging the first (6 specimens) with APF gel for (1min), the second (6 specimens) recharged with APF gel for (4min). specimens recharged with APF gel by immersion the specimens in gel (6 specimens for 1 min and 6 specimens for 4 min) then also wash it with 2ml of de ionized water finally put it in new container contains 5ml of de ionized water and leaving it for 24hr to check the amount of fluoride release after recharging.¹¹ Fluoride Ion Selective Electrode (FISE) used to measure the amount of fluoride released from (GIC) after recharging with APF gel. The (FISE) give the result in (m.v) that were changed it in PPM by use an equation in excel. The same procedure repeated for the one week groups and one month groups (before 24hr of reading transport the specimens in new container contains 5ml of fresh de ionized water then measure the release of fluoride).¹²



III. STATISTICAL ANALYSIS:

The data were analyzed utilizing SPSS program version 26 (U.S.A) which included the following: 1- Descriptive Statistics: which include mean, number of specimens, standard deviation (SD), amount of fluoride release from GIC and amount of fluoride after recharging with APF gel in ppm.

2- Duncan’s Multiple Range test: These data were analyzed by the Duncan’s multiple range

tests to observe the significant differences among the Groups. Results were considered significant when $P \leq 0.05$.

IV. RESULTS

A test of normality by kolmogorov-smirnov and shapiro-wilk was performed on the data, the results were significant $P \geq 0.05$, which indicated that the data was normally distributed.

Table (1) Comparative Evaluation of The Release and Recharge of GIC after 24hr.

		N	Mean	t-value	sig	Std. Deviation
release group1	1 min	6	8.1078	-1.176-	.267	.03814
	4 min	6	8.1322	-1.176-	.267	.03339
recharge group1	1 min	6	8.7325	-3.648-	.004*	.20682
	4 min	6	9.1240	-3.648-		.16224

* Significant ($P \leq 0.05$)

The statistical analysis displayed there was no significant differences in the release of fluoride from GIC at two different durations , a significant difference was observed in the recharge of APF gel at the two different durations (1min-4min).

glass ionomer with APF gel according to Duncan Multiple Range Test, no difference in the amount of fluoride release was observed, but differences in the recharging abilities of GIC restoration appeared, as the release of fluoride was highest after recharging with APF gel for 4 min (9.124) followed by 1 min of APF gel(8.732)ppm

Table (2) displays the mean and standard deviation of fluoride release and recharge from

Table (2) Duncan Multiple Range Test (mean and Std. Deviation of fluoride release and recharge) after 24hr.

group1		release	recharge	mean
1 min	Mean	8.1078 c	8.7325 b	8.4202 b
	N	6	6	12
	Std. Deviation	.03814	.20682	.35570
4 min	Mean	8.1322 c	9.1240 a	8.6281 a
	N	6	6	12
	Std. Deviation	.03339	.16224	.52987
Total	Mean	8.1200 b	8.9282 a	
	N	12	12	
	Std. Deviation	.03646	.27057	



Table (3) Comparative Evaluation of The Release and Recharge of GIC after one week.

		N	Mean	t-value	sig	Std. Deviation
release group2	1 min	6	7.8323	-1.081-	.305	.02988
	4 min	6	7.8482	-1.081-	.309	.01988
recharge group2	1 min	6	8.9573	1.436	.182	.19491
	4 min	6	8.8072	1.436	.182	.16627

The statistical analysis displays there was no significant differences in the release of fluoride from GIC , and no significant differences were observed when recharging the GIC with APF gel(1min-4min).

glass ionmer restoration with APF gel after 1 week,according to Duncan Multiple Range Test, no difference in the amount of fluoride release was observed, no difference were observed between the samples that were recharged with APF gel with 1min or 4min durations.

Table (4) displays the mean and standard deviation of fluoride release and recharge from

Table (4) Duncan Multiple Range Test (mean and Std. Deviation of fluoride release and recharge) after One Week.

group2		release	recharge	mean
1 min	Mean	7.8323 b	8.9573 a	8.3948 a
	N	6	6	12
	Std. Deviation	.02988	.19491	.60237
4 min	Mean	7.8482 b	8.8072 a	8.3277 a
	N	6	6	12
	Std. Deviation	.01988	.16627	.51339
Total	Mean	7.8402 b	8.8822 a	
	N	12	12	
	Std. Deviation	.02557	.18970	

Table (5) Comparative Evaluation of The Fluoride Release and Recharge of GIC after One Month.

		N	Mean	t-value	sig	Std. Deviation
release group3	1 min	6	7.7075	-8.640-	.000**	.03308
	4 min	6	7.8615	-8.640-	.000**	.02849
recharge group3	1 min	6	8.9942	-1.027-	.329	.17963
	4 min	6	9.0755	-1.027-	.340	.07318

****Highly Statistical Significant**

There was a highly statistically significant differences in the release of fluoride from GIC in APF gel group(1min-4min) was noticed ,there was no significant differences when recharging the GIC with APF gel(1min-4min).

Table (6) displays the mean and standard deviation of fluoride release and recharge from glass ionomer with APF gel after one month , there was little difference in amount of fluoride release, but difference in the recharging abilities of GIC restoration appeared.



Table (3) Duncan Test (mean and Std. Deviation of fluoride release and recharge) after One Month.

group3		release	recharge	mean
1 min	Mean	7.7075 c	8.9942 a	8.3508 b
	N	6	6	12
	Std. Deviation	.03308	.17963	.68313
4 min	Mean	7.8615 b	9.0755 a	8.4685 a
	N	6	6	12
	Std. Deviation	.02849	.07318	.63620
Total	Mean	7.7845 b	9.0348 a	
	N	12	12	
	Std. Deviation	.08564	.13749	

V. DISCUSSION

Dental caries is still a serious problem for a lot of children and teenagers, despite having shown that its prevalence has gradually declined in some countries. Therefore, if left untreated, it can result in severe discomfort, pain and have a negative effect on the oral health-related quality of life.¹³ Fluoride is the most advantageous topical agent which inhibits microbial development and metabolism in addition to increasing remineralization to have an anti-caries effect.¹⁴ The most widely utilized fluoride application agent is APF gel 1.23% because of its stability and widespread commercial availability, fluoride ions replace the hydroxyapatite mineral to create fluoroapatite, which is more strong and acid-resistant, the gel contains acid phosphate, which erodes the tooth enamel allowing the fluoride to be incorporated in the enamel structure.¹⁵ APF gel's benefits include the fact that it can be used 2-4 times per year, although it is self-applicable, stable and do not stain, its limitations are an acidic and unpleasant taste, glass cannot be used as a glass container, it is expensive and takes more time to sit on the chair, a clinical investigation found that even though APF is helpful at preventing caries, it should only be used twice annually.¹⁶ An ideal requisite for any type restorative material is that it should have good color stability, it should be biocompatible, have a coefficient of thermal expansion nearly the same as to that of natural teeth, have an excellent marginal seal, in addition to the ability to adhere chemically to both enamel and dentin.¹⁷ Most of the physical and chemical properties make glass ionomer cements excellent dental restorative materials for pediatric patients and it has been used clinically for over 25 years. GICs provide a slow release of fluoride that produces a cariostatic action, chemically bind to enamel and dentin reducing the need for the

preparation of a retentive cavity preparation and are biocompatible with the pulpal tissue. The current study evaluated the amount of fluoride released from the GIC restorative material at different times one day, one week and one month and its recharging ability with APF gel at different duration. There were no adhesives or moisture-contamination-preventing agents applied to the study's specimens in the current study. Numerous techniques, including spectrophotometry, ion chromatography, fluoride ion-selective electrodes, and capillary electrophoresis, have been used to calculate the amount of fluoride released.¹⁸

This study used a fluoride ion-selective electrode because it is easy to use, inexpensive and doesn't require the use of complex lab apparatus. Additionally, it provides a direct and accurate estimation of the amount of free fluoride in the solution. The initial burst is a phenomenon where GIC releases the most fluoride in the first 24 hours during the early setting time.¹⁴ The burst effect may be caused by the first surface rinsing effect, but the decreased fluoride release after the first day may be caused by the fluoride ion diffusing through cement pores and fracture lines, in general the quantity of fluoride released is proportional to the amount of fluoride that exists in the cement. Deionized water, artificial saliva, lactic acid, and other storage medium can all affect how much fluoride is released from a material. In this research, there was a slight variation in the quantity of fluoride released between a one day and a month. However, the difference did not surpass 0.5 parts per million (ppm). It is noteworthy that the burst effect was not particularly noticeable since the fluoride release did not exceed 8.132 ppm. The difference before and after recharging with APF gel was approximately 1 ppm within a day, a week and a month. The fluoride recharging of GIC is influenced by a number of factors, including the material type,



fluoride concentration in the recharging agent and frequency of exposure. It has been demonstrated in the past that greater medium concentration causes more GIC recharging. In the current study de-ionized water was used as storage medium and during measurement. Due to the loosely bound water that can be exchanged with the surrounding medium via passive diffusion, GIC has a good ability to absorb and release fluoride. Previous studies have shown that materials with high initial fluoride release typically exhibit higher fluoride affinities as well as recharge abilities.^{14, 19} De-ionized water was used in this study as a storage medium due to the absence of ions and give very accurate assessments of fluoride release. this is in line with other study.²⁰ Saliva as a storage medium could have a negative impact on the study's findings due to the effect of any minerals or chemical compounds that may be present in the saliva this is in agreement with other study.²¹

Fluoride Release after Recharging GIC Restoration with APFGel for durations (1min-4min).(through One Day, One Week And One Month: There is no similar studies to compare the results of the amount of fluoride release from GIC after recharging it with (APF) gel at different durations. The study found that the amount of fluoride released from GIC decreased over time. After the initial application, there was sufficient amount of fluoride release in the first day. However, this amount began to decrease over time. The duration of recharging with APF gel also influenced the fluoride release from GIC. After recharging with APF gel for 4 min, a higher amount of fluoride was released compared to recharging for 1min. However, after one week, there was little difference in the amount of fluoride released between the two durations. After one month, the fluoride release from GIC after recharging for 4 min was higher than after recharging for 1 min. In deionized water, approximately 1ppm of fluoride was released from GIC after recharging with APF gel for both durations (1 min and 4 min). These findings highlight the importance of considering the duration of recharging with fluoride when using GIC in dental care. Longer contact durations can result in increased fluoride uptake, which may be beneficial for patients who require higher levels of fluoride for preventive purposes. According to the result this was evident in the 24 hour group recharge group and another study²¹ that concluded that the studied material (GIC) first produced high amount of F ions, which quickly decreased, but it continued to release little amounts of F ions throughout the study time. The pH, dose,

concentration, duration, and frequency of treatment all affect how much fluoride is released after topical application. This study contradict with the results of Takahashi et al²² that found that amount of fluoride release is proportional with fluoride concentration. Our study is in line with Nagi et al²³ study that revealed on the first day after being recharged with APF gel ,d the highest statistically significant mean values of fluoride release was evident , followed by a sharp decline. This might be attributed that the short fluoride recharge time (4 min) that was applied to the specimens in this investigation only recharged the outermost layer of the samples. These findings suggest that the choice of recharging duration can impact the fluoride release of GIC. Overall, this study supports the idea that there are limited differences in fluoride release based on recharging durations.

Within the limitation of the present research , fluoride gel proved to be suitable for recharging the GIC restoration at the two different times, the study recommends taking into consideration the age of the patient and their ability to swallow when selecting a recharging material. For children over 6 years old, recharging with APF gel may provide a suitable fluoride release. This is important because fluoride is known to have beneficial effects on dental health, such as preventing tooth decay.

VI. CONCLUSIONS:

The fluoride release from a tooth colored restoration (glass ionomer) after 24 hours was higher than after one week and after one month. The recharge ability of the restorative material(GIC) after APF gel application for (4min) higher than (2min) while no significant difference was observed in the one week, one month recharge was seen .

SUGGESTIONS: Other types of topical fluoride such as dentifrice can be studied to determine the recharging abilities of GIC restoration. Extracted tooth can be used instead of polyethylene mold. Artificial saliva can be used instead of de-ionized water as a storage medium. Determine the amount of fluoride release and recharge for other extended periods of time like 3 month, 6 month and one year. Determine the release of fluoride and the recharging characteristics of GIC restorative at different pH.

LIMITATION OF STUDY:

The study have certain limitation and difficulty during the procedure for example the preparation of polyethylene mold during cutting by



engine to get an accurate mold with 2mm in height , also did not use in vivo study because fluoride release from GIC restoration was difficult to measured and not obtain an accurate result because saliva may have ions , so in vitro study was used.

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