Effect Of Fluoride Release Of Different Restorative Materials On Remineraliation Of Dentin

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Abstract: Background: Dental caries is one of the most prevalent chronic diseases affecting humanity, its progression or control depends on the balance between pathological and protective factors, and the best strategy for caries management is focused on methods of improving the remineralizing process. Three different fluoride restorative materials were used and compared to study the effect of fluoride release on remimeralization of dentin. **Objectives:** To evaluate the fluoride release of three different fluoride releasing restorative materials, Fuji IX GC, Fuji II LC and Beautifil injectable and their effects on remineralization of dentin before and after recharging. **Materials and Methods:** The experiement required measurement of cumulative fluoride release, through a microprocessor based portable fluoride meter by subjecting three groups of fluoride release restorative materials (Fuji IX GC, Fuji II LC and Beautifil injectable) to pH cycling three times daily for twenty minutes between the artificial saliva for neutralization at pH 7 and citric acid at PH4. The cumulative fluoride release measured at one week, four weeks and twelve weeks. The remineraliation of dentin is assessed through dentin restorative materials samples exposed to pH cycling and measured by measurement of fluoride uptake into dentinal tubules at one week and twelve weeks before and after recharging. Through using quantitative environmental scanning electron microscope (QESEM). **Results:** Regarding cumulative fluoride release assessment Fuji IX GC is the highest statistically significant than other tested fluoride releasing restorative material at the three aging periods tested at this study and at the two aging media exposed the three tested materials ,and regarding fluoride uptake assessment beautifil injectable highly significant difference than other two tested restorative materials at both aging periods and both aging media tested at this study. Also, the results revealed that there was no statistically significant difference between fluoride uptake values after recharging. **Conclusion:** Under the circumstances of this study conventional glass ionomer restorative material is the martial of choice regarding fluoride release represented by Fuji IX GC, the glass ionomer modified resin composite (Giomer represented by newly introduced beatifil injectable) has the advantage of fluoride uptake and remineralization.no statistical significance before and after recharging of glass ionomer rstoratives.

Keywords: Giomr,Fluoride release, Fluoride uptake, Remineralization.

1. Introduction

Dental caries is one of the most prevalent chronic disease affecting humanity. Its progression or control depends on the balance between pathological and protective factors, and the best strategy for caries management is focused on methods of improving the remineralizing process[1]. Tooth remineralization is a naturally occurring process in the oral cavity[2]. It is defined as a process in which calcium and phosphate ions are sourced to promote ion deposition into crystal voids in demineralised enamel. Remineralization remains imperative towards the management of non-cavitated carious lesions and prevention of disease progression within the oral cavity. The process also has the ability to contribute towards restoring strength and function within tooth structure[3]. Tooth demineralization chemical process by which minerals (mainly calcium) are removed from any of the hard tissues - enamel, dentine, and cementum[4]. The process of demineralization begins at the crystal surface found inside the hard tooth tissue and may progress into cavitation unless arrested or overridden by remineralization. The effect of demineralization can be reversed if there is sufficient time to allow remineralization to occur to counteract the acids in the oral cavity[5]. Together, demineralization and remineralization contribute towards a dynamic process[6]. When a restorative intervention is necessary, the use of materials with minimal aggression to the tooth structure and cariostatic, adhesive, and biocompatible properties must be prioritized[7]. Glass ionomer restoratives and their derivatives of fluoride releasing restoratives including resin modified glass ionomer, polyacid-modified resin composite compomer, and composite resin containing pre-reacted glass inomer fillers (giomers) have been largely used in restorative dentistry because of their ability to reduce the incidence of caries affecting un restored tooth surface[8]. Fluoride ions are essential elements in prevention and treatment of dental caries, by inhibition of demineralization through penetration along with the acids at the subsurface, absorb apatite crystal surface and protect surface from dissolution[9]. Fluoride enhances in elevation of the pH acidic media of oral environment to 5.5 or above, the saliva which is supersaturated with calcium and phosphate, forces mineral back into the tooth and fluoride absorbs to the surface of partially demeneralized crystals forming fluroapatite crystals which is more resistance to the acid drop[10]. There are contraverses about the effect of fluoride on enamel and dentin even with low fluoride concentration which may lead to hypermineralization of dentin,on give the material a cariostatic effect[11]. However, the appropriate amount of fluoride release required to obtain the beneficial effect, was a bit wandering to the amount that was really released[12]. In spite of the fact that fluoride releasing products directly contact the cavity wall, but there is little evidence regarding their diffusion and their effect on surrounding tooth structure[13]. The ability of a restorative to act as a fluoride reservoir is mainly dependent on the type and permeability of filling materials, on the frequency of fluoride exposure and on the kind and concentration of fluoridating agent[14]. Various methods of aging (deionized water, distilled water and artificial saliva), periods of aging (days or months) and methods of fluoride recharge are contributing factors[15]. From the previous review, it was speculated that it would be of importance to evaluate the effect of fluoride release of different restorative materials on remineralization uptake of dentin. through measurement of Measurement of fluoride release of each restorative material used in this study, Measurement and comparing fluoride uptake remineralization of dentin before and after recharging.

2. Materials and Methods:

Three Restorative materials used in this study; Conventional glass ionomer system, Fuji IXGC capsule with its. GC conditioner. Resin modified glass ionomer, Fuji IILC capsules. Glass ionomer modified resin composite, giomer, ,Beautiful injectable restorative material with its FL-Bond II bonding agent. Three Solutions used for pH cycling, Citric acid at pH 4, artificial saliva at pH 7. Two standard fluoride calibration solutions HI70702 and HI70703; were used for checking the electrode potential and calibrating the fluoride meter. TISAB (total ionic strength adjustment buffer); it was used for measuring fluoride ions as it provides a constant background ionic strength.

1. Assessment of fluoride release

1.1. Grouping of specimens:

A total of 30 specimens were prepared in this study, they were divided into three equal groups according to the type of the restorative material used Fuji IX, Fuji II LC and Beautifil injectable, specimens of each group were divided into two subgroups (five specimens each) according to the immersion media; either artificial saliva or citric acid,the specimens of the subgroup artificial saliva were always kept immersed in the artificial saliva at pH 7 the specimens of the subgroup citric acid were exposed to pH cycling between the artificial saliva at pH 7 and the citric acid at pH 4. For each group the cumulative fluoride release was assessed at one week, four weeks and twelve weeks.

1.2. Specimen preparation:

A specially designed Teflon mold was used to prepare the specimens discs. The mold was 2mm thick and has a circular hole in its middle with an internal diameter of 3mm. The Teflon mold was placed on a glass slab over a transparent polyester strip, and then the material was packed and the excess was removed using sharp # 12 bard barker scalpel blade. Another polyester strip and another glass slab were placed on the top of the mold; to ensure surface smoothness a constant 200g load was applied**.** After the removal of the upper glass slab, the material was light cured with LED visible light curing unit (500mW/cm2 intensity) at zero distance according to the manufacturer's instructions except for the chemically cured conventional glass ionomer (Fuji IXGC) material which was left to set at room temperature.

1.3. Storage of specimens:

Each specimen was placed in a glass tube containing 5ml artificial saliva which was changed weekly and stored at room temperature. All tubes were properly covered with rubber stoppers to prevent evaporation. Specimens of the subgroup; M1 the immersion media was artificial saliva at pH 7, throughout the whole study period. While specimens of subgroups M2 citric acid were exposed to pH cycling regimen; between citric acid at pH 4 and artificial saliva at pH 7. The pH cycling regimen consisted of three cycles in acidic medium; in which the specimens were immersed in 5ml of the acid for 20 minutes three times daily with the intervening period in the artificial saliva. This pH cycling protocol was done at room temperature and repeated daily for 12 weeks.

1.4. Fluoride release assessment:

The artificial saliva was analyzed for fluoride with the use of microprocessor based portable fluoride meter * figure (1). Through the use of the ion specific electrode (a) connected to a microprocessor based portable fluoride meter (b). Every week prior to fluoride release measurements from the different materials, the fluoride meter was calibrated. The calibration was in the middle of the range at 100mg/L (ppm) using 100 ppm fluoride solution (HI 70703) and the other point was selected for low fluoride measurements at 10 mg/L (ppm) using 10 ppm fluoride solution (HI 70702). In order to obtain an accurate result, the meter was calibrated at a temperature not more than 20±3°C. A separate stainless steel temperature probe (c) was supplied and connected to the meter. It was used to measure and adjust the temperature of the artificial saliva. The reading was shown on the lower part of liquid crystal display. A separate reference electrode (d) was also supplied and connected to the portable fluoride meter. It was immersed with the fluoride electrode and the temperature probe in the sample solution during measurement of fluoride concentration in order to guarantee an accurate and repeatable measurement every time. The 5 ml storage medium of each specimen was added to 0.5 ml of readymade total ionic strength adjustment buffer solution TISAB II (HI 4010-05) in ratio 10:1 according to the manufacturer's instructions. The three connected electrodes were properly immersed in the solution in order to assure accurate readings of fluoride released in the artificial saliva. The results were displayed on the upper part of liquid crystal display (LCD) directly in fluoride concentration and expressed in ppm (mg/L).

***Figure (1): A** microprocessor based portable fluoride meter.*

2. Assessment of fluoride uptake of dentin, remineralization assessment

2.1. tooth selection:
Non-carious and non-restored freshly extracted human posterior teeth were used in this study. After extraction, the teeth were thoroughly washed under running water to remove soft debris. Defected or cracked tooth was excluded and replaced by another one. The teeth used for this study were stored in deionized distilled water at room temperature till the start of the study.

2.2. Grouping of specimen:
A total of 48 specimens were prepared in this study, they were divided into three equal groups according to the type of restorative material used Fuji IX, Fuji IILC and Beautifil injectable 18 specimens each. Each group were divided into two subgroups nine specimens each according to the immersion media, either artificial saliva or citric acid. Each subgroup was classified into three classes according to storage period three specimens each either one week, four weeks, and twelve weeks which represent specimens that was measured after fluoride recharging. Following each storage period the teeth were sectioned and the amount of fluoride uptake was assessed at the axial wall of the cavity at distance 50 uµ from dentin/restoration interface.

2.3. Specimen preparation:
Each tooth was prepared for standardized class V cavity preparation (2 mm diameter and 1 mm depth). Application of the restorative material into the prepared cavities were done according to the manufacture instruction. GC Fuji conditioner was applied to the cavities using microbruch for 10 seconds at the sample which restored with Fuji IX GC according to manufacturing and then rinsed with copious amount of water.

2.4. Restoration of prepared:
Before bonding procedures the prepared cavities were cleaned using air/water spray then blot dried with a cotton pellet. Application of the dental restorative materials tested in each group was manipulated according to the manufacturer's instruction. Then after the application of the three tested restorative materials, two coats acid resistant nail varnish was applied one mm away from the cavity margin on all the teeth surfaces.

2.5. Storage of the teeth:
Each tooth was placed in a glass tube containing 5 ml artificial saliva which was changed weekly and stored at room temperature. Teeth of the subgroup artificial saliva, the immersion media was artificial saliva at pH 7, throughout the whole study, while of subgroup citric acid were exposed to pH cycling between citric acid pH 4 and artificial saliva at pH 7 at artificial saliva. This pH cycling were done 20 minutes daily, 3 times daily. This pH cycling protocol was done at room temperature and repeated daily for 12 weeks. Fresh solutions citric acid according to the subgroup were used and was changed three times daily, the pH of the new solutions were measured using pH meter to avoid any change in the pH. Teeth of the two classes periods of one week and four weeks collected after the completion of the different storage periods for the fluoride uptake measurement. While in third class which represented the recharging specimens at twelve weeks; teeth were exposed for twelve weeks of the same regimens used with the other two classes. After the twelve weeks period, teeth were exposed to a topically applied fluoride regimen using Clinpro White varnish (3M ESPE, St Paul MN, USA). Then the varnish was applied evenly to the teeth for 15 minutes each as recommended by the manufacturer. After water flushing, each specimen was stored again in its glass test tubes containing 5 ml artificial saliva at room temperature. Specimens were then exposed again to the same regimen for an additional of four weeks.

2.6. Specimens preparation for fluoride uptake and recharging assessment:
The specimens were then placed on stainless steel stubs and examined by Quanta Environmental Scanning Electron Microscope (QESEM) Figure (2), to determine the percentage of fluoride uptake by dentin before and after recharging.

Figure (2): *Quanta Environmental Scanning Electron Microscope (QESEM).*

2.7. Fluoride uptake analysis:
The fluoride uptake analysis was carried out using the QESEM. Scanning quantification were performed along the restoration/tooth interface to measure the amount of fluoride uptake by dentin axially at depth of 50 µm from the interface (represented by weight percentage). Spot analysis was done at three points occlusally, cervically (100 µm away from the axial line angles) and in the middle of the axial wall at 200X magnification and at voltage 15.00 KV. The weight percentage of fluoride was quantified with other elements (O_2, Na, Al, Si, P and Ca). This quantification results provided normalization to 100% for all the selected elements. The fluoride with other elements was presented in a spectrum curve with identification peaks and in a quantified result box. Three reading of fluoride Wt% were averaged to obtain one reading from each specimen.

Statistical analysis:
Three-way Analysis of Variance (ANOVA) was used for studying the effect of material, storage media, storage period and their interactions on different variables. For cumulative fluoride release, Bonferroni test was used for pair-wise comparison between the mean values when ANOVA test is significant, while Tukey's post-hoc test was used for pair-wise comparison between the mean values when ANOVA test is significant for fluoride uptake. Detailed comparisons between materials, storage media and storage periods were

performed using Kruskal-Wallis test followed by Mann-Whitney U test, for the cumulative fluoride release data. While for fluoride uptake, detailed comparisons between materials, storage media and storage periods were performed using one-way ANOVA test followed by Tukey's test. In addition, paired t-test was also used to compare between fluoride uptake after 12 weeks and after recharging.

3. Results:

For the fluoride release results:
The results showed, the means and standard deviation (SD) of the cumulative fluoride release values in ppm demonstrating the effect of the different tested materials; on the mean fluoride release irrespective of other variables. It was revealed that conventional glass ionomer Fuji IX GC showed the statistically significant highest mean cumulative fluoride release followed by resin modified glass ionomer Fuji IILC, while glass ionomer modified resin composite Beautifil II) showed the statistically significant lowest mean cumulative fluoride release at $P < 0.001$. The results also showed that after storage in artificial saliva for one week, four weeks and twelve weeks; conventional glass ionomer Fuji IXGC, showed the statistically significant highest mean cumulative fluoride release values. There was no statistically significant difference between resin modified glass ionomer Fuji IILC and glass ionomer modified resin composite Beautifil II; both showed the statistically significant lowest mean cumulative fluoride release values at four weeks and twelve weeks Also, the results showed that after pH cycling in citric acid for one week, four weeks and twelve weeks; conventional glass ionomer ,Fuji IXGC ,showed the statistically significant highest mean cumulative fluoride release values There was no statistically significant difference between resin modified glass ionomer (Fuji 2lc) and glass ionomer modified resin composite (Beautifil II); both showed the statistically significant lowest mean cumulative fluoride release values (0.71±0.05ppm and 0.86±0.27ppm) respectively at one week, (3.26±1.07ppm and 2.83±0.90ppm) respectively at 4 weeks and (11.39±4.28ppm and 9.48±3.27ppm) respectively at 12 weeks.

Table (1): *The mean cumulative fluoride release ± standard deviation (SD) values in ppm and results of comparison between materials irrespective of other variables in the study.*

Conventional glass ionomer (FUGI IXGC)		resin modified glass ionomer (FUJI IILC)		Glass ionomer modified resin composite (Beautifil I1)		P-value
Mean	SD	Mean	SD	Mean	SD	
7.17	6.12	4.98	3.89	4.44^c	3.96	< 0.001*

**: Significant at P ≤ 0.05, Different letters are statistically significantly different*

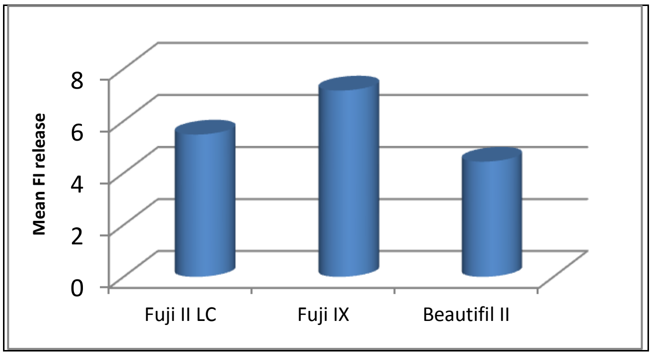

Figure (3): *Bar chart representing the effect of the three tested materials on the mean cumulative fluoride release values in ppm irrespective of other variables in the study.*

For the cumulative fluoride uptake remineralization results:
The data showed the means and standard deviation (SD) of the fluoride uptake values in Wt% demonstrating the effect of the different tested material on the mean fluoride uptake irrespective of other variables in the study. Descriptive statistics and the test of significance were performed using Tukey's post-hoc test for pair-wise comparison, the mean fluoride uptake values were also plotted in bar chart. The mean of fluoride uptake values of conventional glass ionomer Fuji IX GC , resin modified glass ionomer Fuji IILC and glass ionomer modified resin composite (Beautifil II) were 2.08±1.59Wt%, 0.85±0.39Wt% and 2.28±0.49Wt% respectively. It was revealed that glass ionomr modified rein composite, showed the statistically significant highest mean fluoride uptake followed by conventional glass ionomer Fuji IXGC, **W**hile resin modified glass ionomer Fuji IILC showed the statistically significant lowest mean fluoride uptake at $P < 0.001$. The results also showed that storage in artificial saliva at one week; glass ionomer modified resin composite (Beautifil II) showed the statistically significant highest mean fluoride uptake value 1.61±0.07Wt%, but there was no statistically significant difference between conventional glass ionomer (Fuji 9) and resin modified glass ionomer Fuji IILC; both showed the statistically significant lowest mean fluoride uptake value (0.76±0.17Wt% and 0.42±0.16Wt%) respectively. At 12 weeks; there was no statistically significant difference between conventional glass ionomer (Ketac Fil) and glass ionomer modified resin composite (Beautifil II); both showed the statistically significant highest mean fluoride uptake value (2.28±0.35Wt% and 1.98±0.70Wt%) respectively, but resin modified glass ionomer Fuji IIlc showed statistically significant lowest mean fluoride uptake value 0.66±0.33Wt%. The results showed that pH cycling in citric acid at one week and 12 weeks glass ionomer modified resin composite Beautifil II,showed the statistically significant highest mean fluoride uptake value 1.66±0.16Wt%, but there was no statistically significant difference between conventional glass ionomer Fuji IXGC and resin modified glass ionomer (Fuji IILC); both showed the statistically significant lowest mean fluoride uptake values (0.84±0.12Wt% and 0.59±0.26Wt%) respectively.

Table (2): *The mean fluoride uptake ± standard deviation (SD) values in Wt% and results of comparison between materials irrespective of other variables in the study.*

Conventional glass ionomer (Fuji IXGC)		resin modified glass ionomer (FUJI IILC)		Glass ionomer modified glass ionomer (Beautifil II)		P-value
Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
2.82^{a}	1.59	0.85^{c}	0.39	3.08^{b}	2.49	< 0.001*

**: Significant at P ≤0.05, Different letters are statistically significantly different*

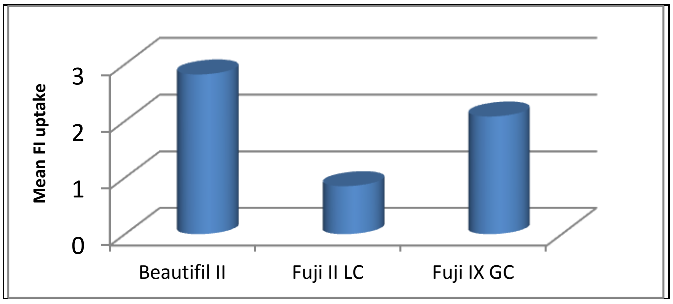

Figure (4): *Bar chart representing the effect of the three tested restorative materials the mean fluoride uptake values irrespective of other variables in the study.*

For the fluoride recharging results:
The results showed that there was no statistically significant difference between fluoride uptake values after 12 weeks and after fluoride recharging in the two tested storage media (artificial saliva, and citric acid), with conventional glass ionomer Fuji IXGC, which was; 3.58±0.31Wt% and 4.09±0.97Wt% respectively for artificial saliva, and 5.05±0.56Wt% and 5.42±0.41Wt% respectively for citric acid. While with, glass ionomer modified resin composite Beautifil II it was; 2.29±0.52Wt% and 3.40±0.26Wt% respectively for artificial saliva, and 2.59±0.59Wt% and 4.34±0.99Wt% respectively for citric acid. For resin modified glass ionomer Fuji IIlc showed that; there was no statistically significant difference between fluoride uptake values after 12 weeks and after fluoride recharging with artificial saliva which was 0.94±0.07Wt% and 1.56±0.55Wt% respectively for artificial saliva and 1.51±0.0.26 and 2.13±0.49 respectively for citric acid.

Table (3): *The mean, standard deviation (SD) values in Wt% and results of comparison between fluoride recharging.*

Material	Storage media	12 weeks		Recharging		P-value
		Mean	**SD**	**Mean**	**SD**	
Conventional glass ionomer (Fuji IXGC)	**Artificial saliva**	3.58	0.31	4.09	0.97	0.054
	Citric acid	5.05	0.56	5.42	0.41	0.101
resin modified glass ionomer (Fuji IILC)	**Artificial saliva**	0.94	0.07	1.56	0.55	0.216
	Citric acid	1.51	0.26	2.13	0.49	0.049*
Glass ionomer modified resin composite (Beautifil II)	**Artificial saliva**	2.29	0.52	3.40	0.26	0.110
	Citric acid	2.59	0.59	4.34	0.99	0.145

**: Significant at P ≤0.05*

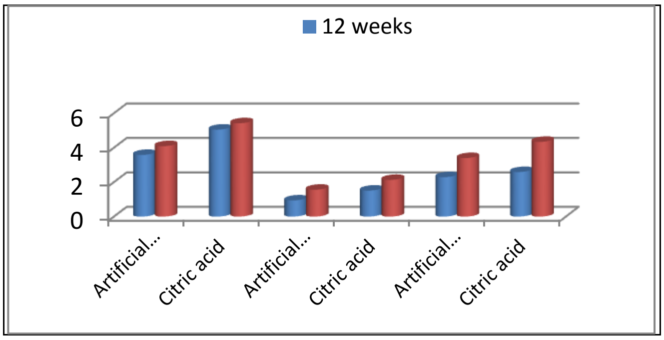

Figure (5): *Bar chart representing comparison between the mean fluoride uptake values at 12 weeks and after fluoride recharging.*

4. Discussion:

Numerous studies on the amount and rate of fluoride release of different glass ionomer formulations and its modifications have been published, but an insight into the mechanisms of the fluoride release and uptake is still lacking, various studies have shown that fluoride releasing restorative materials are very effective in inhibiting caries and making tooth substrates much more reactive for remineralization[16]. Several investigation have been performed on fluoride ion release from restorative material, as this property is related to their cariosatic effect[17]. The fluoride ion release of from dental restorative is governed by intrinsic and extrinsic factors[18]. The intrinsic factors depend on composition, powder liquid ratio, specimens geometry, temperature surface treatment, permeability and finishing However the extrinisic factors may include type of storage medium and time period of studied assessment, and include analytical methods. Since fluoride release is considered essential property in glass ionomer restorative materials, this study was carried out to elaborate the cumulative fluoride release from newly introduced product of Giomer product, claimed its ability to release fluoride, remeneralize the enamel and dentin and so increase hardness and catalyze rminralization of hard tooth structures around cavity margins[19]. The assessment of fluoride release was carried out using the most tradition method and most frequently in-vitro method for fluoride ion concentration detection in solution for its sensitivity & its high precision[20] Fluoride release from different fluoride releasing restorative material would be valuable property if it is up taken by tooth substrates allowing its remeneralization and increase its resistance to acidic attack by cariogenic bacteria. Fluoride uptake by human dentin was assessed by quantitative scanning electron microscope (QESEM)[21]. The pH cycling protocol done between artificial saliva and the citric acid. Selection of citric acid stimulate the effect of citrus food, juices and carbonated beverages[22]. The pH cycling was carried out three times daily a day, i.e., three meals time periods; Breakfast, Lunch and Dinner to stimulate the pH experienced in the oral environment during consumption of fermentable food, stuffs[23]. In the current study, the results revealed that, the highest amount of cumulative fluoride release was recorded for the conventional glass ionomer Fuji IXGC, followed by resin modified glass ionomer Fuji IILC, followed by glass ionomer resin composite (Beautifil injectable), The amount of fluoride made available to the oral cavity is not related only to the content of the material, but also to the ability for fluoride to leach from the restorative material[24]. Two mechanisms have been proposed by which fluoride may be release from the restorative material into an aqeous environment the first mechanism is short durable, short term reaction which involves initial burst effect and rapid leach dissolution of the glass particles attacked by acid reaction, the second mechanism is long durability and more gradual and sustained long term diffusion of ions through the bulk of the cement[25]. According to the results,the two mechanisms typically found with conventional and resin modified glass ionomer as acid base reaction by the proton attack at the surface which lead to the subsequent fluoride ions liberation from the fluoroglass particles, the leached Ca, Al ions from a polysalts with fluoride ions which are dispersed homogenously through the matrix regions of the set cement, seems to be responsible for the short term elution process and the initial burst effect[26]. While in case of glass ionomer modified resin composite (Beautifill injectable), the setting through free radical polymerization reaction without proton attack acid base reaction, so the only source of fluoride would come from the glass filler particles and so slow diffusion release[25]. Technology (SPRG) i.e., surface prereacted glass particles in glass ionomer resin composite (Beautifil injectable) so the set matrix is relatively the same of conventional resin composite i.e., hydrophobic resin monomers lead to less water sorption and subsequently less fluoride release because of lack of acid-base reaction because of S-PRG prereacted already with flurosilicate glass particles[27], so in turn affects the long term fluoride release. This result is in accordance with[28], whom found that glass ionomer modified resin composite release less fluoride than conventional glass ionomer Fuji IXGC all over the time and attributed their finding to the presense of S-PRG The results also revealed that the highest amount of fluoride release, and the highest amount of fluoride uptake weight percentage of fluoride in the dentin were evident in citric acid with its pH acid value more than normal neutral artificial salvia for all fluoride releasing restorative materials used in the current study, this result was in agreement with Kantoviz et al.[29] conserned fluoride release results. This could be attributed to that citric acid is strong organic acid, as it can be used in manufactures of beverages and foods according to Wang and Yap[30], who found that every decrease in pH value as described in the current study at citric acid pH 4 lead to increase the solubility and disintegration of the material, as the low acidity have the ability to erode the glass ionomer materials, and so the increase in fluoride ion release and increase its weight percent inside the dentinal tubules Another explanation is that the relatively acidity of the citric acid which make it able to react with basic glass fillers to form ca and aluminum acid salts[31]. The artificial saliva in this study was used in high pH 7 and considered controllable group according to the results of that study. Bell et al.[32] found that fluoride release decrease after immersion of the specemins in the artificial saliva, there concluding their findings due to the retarding effect of the artificial saliva as a result of the formation of surface deposits, Hattab and Amin[18] was in agreement with that finding he found that released fluoride ions might react withcalcium ions present in artificial saliva with formation CaF2, surface coating on the speciemens that could act as a diffusion barrier. Glass ionomer modified resin composite (Beautifil injectable) showed the highest amount of fluoride uptake at period of one week followed bu conventional glass ionomer (Fuji IX GC), while resin modified glass ionomer (Fuji II LC) is the lowest percentage in fluoride uptake in dentin. While at twelve weeks, conventional glass ionomer (Fuji IX GC) showed the highest amount of fluoride uptake followed by glass ionomer resin composite (Beautifil injectable) However resin modified glass ionomer (Fuji II LC) showed the lowest percentage in fluoride uptake at the all testing periods in dentine. The results in agreement with previous researches published by Hotta et al.[33]. This may be attributed to that fluoride uptake by the adjacent dental tissues is highly influenced by the quality of tooth restoration interface. The Beutifil injectable adhesive system contain 4-acrylooxyethyltrimellitic acid (4 AET) monomer is able to interact chemically with both hydroxyapatite and collagen fibrils. The two ionized carboxylic groups of (4-AET) molecule can react with Ca ctions of the original and remnant appatites and form Ca carboxylates salts[34]. This suggests that this adhesive systems allow formation of two fold bonding mechanisms micromechanical and chemical bonding via the formation of dentin impregnated dentin layer (Hyprid layer) and chemical bonding via the acidic monomer[35]. Fluoride impregnation in the dentin substrate surface would be as a consequence of the perentration of the low viscosity flowable resin into the dentinal tubules, resulting in resin tag formation, which suggests a second process of fluoride diffusion[36]. This result could be attributed to fluoride content in the self etch adhesive (FL bond II) which used with Beautifil injectable, in a form of pre-reacted glass ionomer fillers and poly acid modified resin filler which are subsequently in corborated inside the hyprid layer. The recharging with fluoride varnish increased the fluoride uptake by the freshly cut dentin with all restorative materials under experimental condition but without statistical significance it could be attributed to two speculations first fluoridation mainly performed to counteract the fluoride loss of material is more likely a surface reaction, thus the inward bulk diffusion is related to the diffusion coefficient of the material, thickness and time of application[37]. Second it was found that the recharging agent contain other ions, these ions may be competing with fluoride ions for binding sites at the filler particle surface, thereby impairing recharging of the materials[38].

5. Conclusion

1. The formulations of glass ionomer restorations has a significant effect on fluoride release and uptake ability of the glass ionomer restorations.
2. Conventional glass ionomer have a higher ability of fluoride release than any modifications of glass ionomer cements
3. Newely introduced glass ionomer modified resin composite giomer have potent effect in fluoride uptake remineralization due to the role of strong impregination bond inside the dentinal tubule.
4. Exposure to acidic media has a great impact on fluoride release and remineralization uptake properties.
5. Topical fluoride application did not enhance fluoride uptake by the tooth dentin

6. Disclosure and acknowledgment

The authors do not have any financial interest in the companies whose materials are included in this article.

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