

Vision is the Art of Seeing Things Invisible - An *invitro* Comparative Evaluation

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ABSTRACT

Background: Restoration failure due to secondary caries is a continuing problem in restorative dentistry.

Aims and objective: The present study is undertaken to see whether various fluoridated dentifrices recharge fluoride releasing restorative materials and, comparatively evaluate their recharging capabilities.

Materials and method: Materials used in the study are Fuji II LC, Compomer, Teethmate F1, Alfadent sealant. Dentifrices used are Sodium fluoride and Sodium monofluorophosphate releasing. All restorative materials were mixed according to manufacturer's instruction and standardized test pellets were made using autoclaved instruments in sterile Teflon moulds. These test pellets were divided in various groups and brushed with various fluoridated and nonfluoridated dentifrices accordingly. Results were evaluated statically using ANOVA, t-test and correlation coefficient for which regression lines were drawn. It was concluded that Sodium fluoride containing dentifrices recharged fluoride releasing restorative material more than Sodium monofluorophosphate containing dentifrices

Keywords: Secondary caries, Fluoride release recharging restorative materials, Dentifrices

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INTRODUCTION

Restoration failure due to secondary caries is a continuing problem in restorative dentistry (1). Secondary or recurrent caries occurs around restorative materials when the interface of the tooth and restorative material is compromised to such a degree that microleakage occurs (2).

The metabolic byproducts of dental plaque bacteria including Lactic acid, Acetic acid and Citric acid penetrate along the tooth-restoration interface and reduce the pH in the microenvironment of the tooth surface, resulting in the demineralization of the dental hard tissue (3).

Hence, to be cost effective, we must aim to fill the carious lesions with those restorative materials that are truly adhesive in nature to prevent secondary caries. But till date no material is truly adhesive. Therefore, until a proven adhesive system is available, there is an increased interest of knowing the mechanisms that inhibit such acid production, increase resistance to demineralization and / or facilitate remineralization of tooth at tooth-

restoration interface, mainly by increasing the anticariogenicity of the restorative material itself (4).

One of the most proven methods is to incorporate fluoride into the structure of the restorative material to make it caries preventive. The ability of fluoride to prevent caries is well established and has been demonstrated through a plethora of studies (4). The materials commonly used as fluoride releasing restorative materials are silicates, conventional glass ionomers (5), resin hybrid glass ionomers (6), fluoride releasing composite resins (7), fluoride releasing pit and fissure sealants (8) etc.

However, according to Eichmiller FC *et al* (9) most fluoride containing restorative materials release fluoride in an initial burst for few days and then reduce exponentially to a much lower steady state level of release. Moreover, caries inhibition and remineralization potential have been shown in vitro by all of these materials.

As this fluoride from the restorative material is leached continuously, there is a



Figure 1: Equipments and Materials used in the study

danger of emptying the fluoride resources after some period of time. If, on the other hand, these fluoride releasing restorative materials are capable of binding fluoride from outside resources and releasing it again, this would ensure a permanent anticariogenic effect. Thus to ensure a permanent anticariogenic effect, a dynamic situation of fluoride release and uptake is desirable.

A number of studies have suggested that there is such an ability of these materials to serve as rechargeable reservoirs, delivering a low level of fluoride to the oral cavity for longer period of time after the ion source has been removed (10-13).

Various studies conducted recently suggest that these fluoride releasing restorative materials can be recharged with fluoride by professional application of topical fluorides like APF gel (14), NaF gel (15) or by daily use of fluoridated mouth rinses (16) or fluoridated dentifrices (11).

It has been observed that professional application of topical fluoride increases fluoride dissemination in the restorative materials immediately, but it gets depleted within 48 hours (12) and it requires patient

compliance also. Hence recharging with professional application of topical fluoride is not of much use.

On the other hand, daily tooth brushing with fluoridated dentifrice may replenish material surface fluoride level at each brushing interval and thus, a reservoir of fluoride could be created for constant release and a certain reduction in caries is evident till the time the restoration is maintained in the oral cavity.

The present study is undertaken to see whether various fluoridated dentifrices recharge fluoride releasing restorative materials and, comparatively evaluate their recharging capabilities.

METHODOLOGY

The restorative materials viz. Fuji II LC, F-2000, Teethmate F-1 and Alphadent (Figure 1) were mixed according to manufacturer’s instructions and 48 specimens (12 of each material) were made using autoclaved instruments in sterile Teflon moulds [4 mm (diameter) x 3mm (ht.)], supported by a glass slide in a mounting jig. A glass slide was placed on the top of the Teflon mould in slot in the jig followed by the tightening of the screw embedded in the vertical arm of the jig to

apply gentle and uniform pressure on the upper slide to extrude the excess material. The specimens were cured using a visible light cure device (Figure 1).

After the materials were set the pellets were removed from the Teflon moulds and placed in separate autoclaved plastic vials containing 10ml deionized water and stored at room temperature (Figure 2). 12 pellets of each material (Fuji II LC, F-2000, Teethmate F-1, and Alphadent) were prepared to make total 48 experimental samples. These samples were divided into four groups:

- **Group I** - 12 Samples of Fuji II LC
- **Group II** - 12 Samples of F-2000
- **Group III** - 12 Samples of Teethmate F-1
- **Group IV** - 12 Samples of Alphadent

Each group was further divided into 4 experimental subgroups with three pellets in each subgroup (Table 1)

Each sample of subgroup IA was picked up by a sterile tweezer, brushed for two minutes with pea sized amount of sodium fluoride containing Pepsodent 2-in-1 toothpaste and then rinsed with 5ml of deionized water and placed again in the same plastic vial containing 10ml deionized water.

Likewise samples of group IB, IC were brushed with Colgate Herbal containing sodium monofluorophosphate and non fluoridated, Close-Up respectively. Samples of ID which were not brushed with any paste were kept as control (Figure 3).

Fluoride ions leached out in the storage media (deionized water) containing

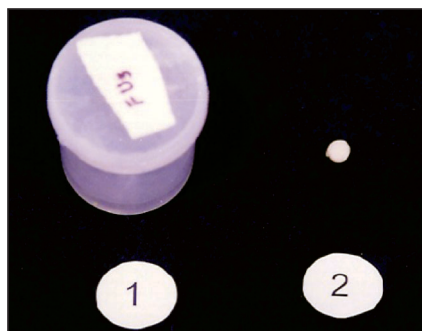
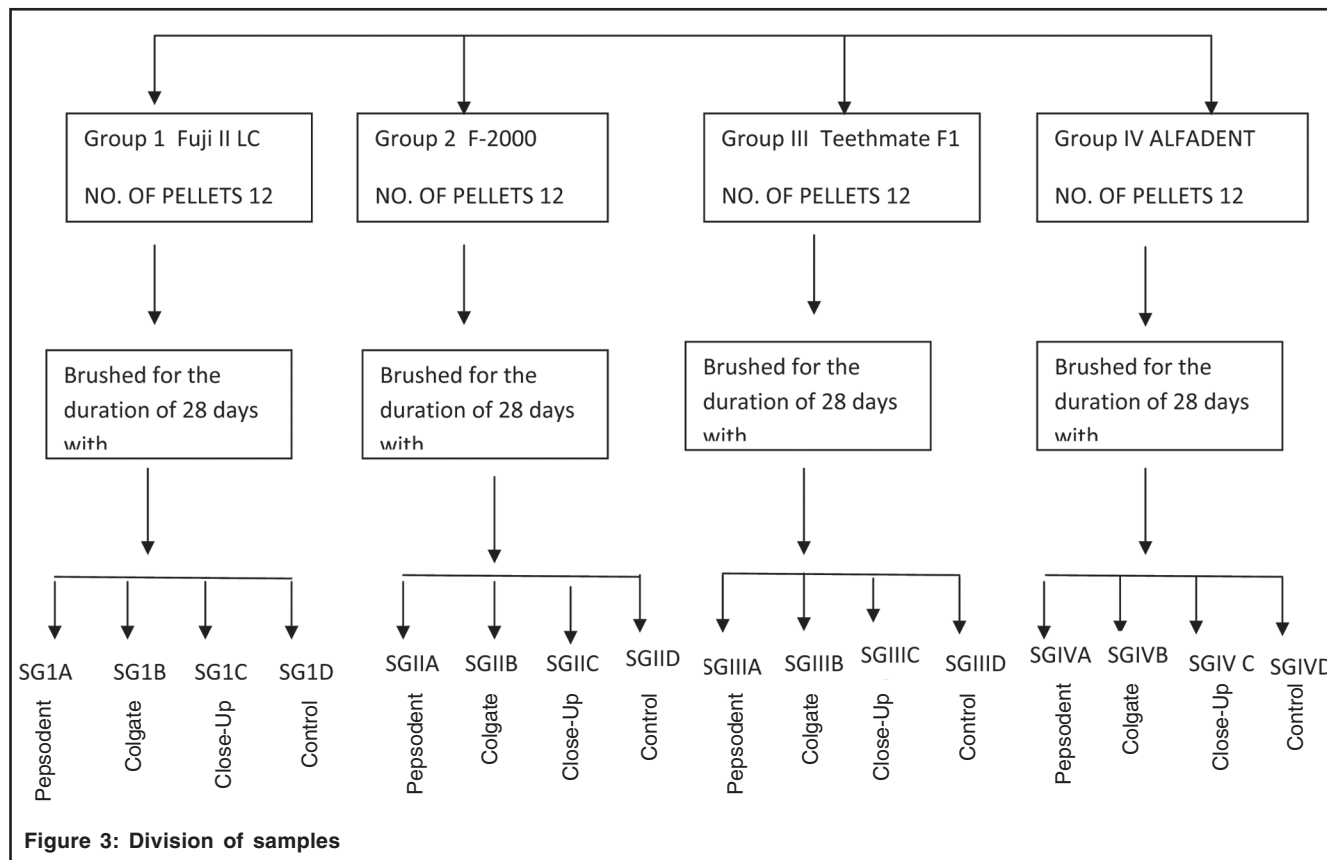


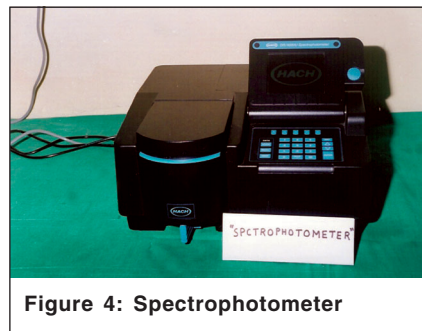
Figure 2: Preparation of samples

Table 1: Division of samples					
Name of Material	Group	Subgroups (Dentifrices)			
		Pepsodent 2-in-1	Colgate Herbal	Close-Up	Control
Fuji II LC	I	IA	IB	IC	ID
F-2000	II	IIA	IIB	IIC	IID
Teethmate F-1	III	IIIA	IIIB	IIIC	IIID
Alphadent	IV	IIVA	IIVB	IIVC	IIVD



restorative material pellets, were estimated after 24 hours (T1), 7th day (T7), 14th day (T14), 21st day (T21), and 28th day (T28) using a standard ion selective electrode method with the help of spectrophotometer (Hach / AU/4000) in parts per million unit (ppm) (Figure 4). After every estimation the pellets were then replaced in the vial, containing fresh 10ml of deionized water.

However, the brushing with specific dentifrices was continued twice daily as described above.



Statistics

The data was statistically analyzed using analysis of variance (ANOVA) test and ‘t’ test. The relation between different groups was obtained by correlation coefficient for which regression lines were drawn.

RESULTS AND OBSERVATIONS

The mean fluoride ion concentration values of various materials when brushed with different dentifrices at various time intervals are displayed in Table 2. It was observed that mean leached out fluoride ion concentration from the glass ionomer cement sample, when brushed with sodium fluoride containing dentifrice was $6.35 \pm .269$ ppm. While the leached out fluoride ion concentration was $4.52 \pm .115$ ppm for glass ionomer cement samples brushed with sodium monofluorophosphate dentifrice and $3.53 \pm .1193$ ppm for those samples which were brushed with non fluoride containing dentifrice New Close-Up. The mean fluoride ion concentration for the samples not brushed with any dentifrice was $3.0 \pm .0500$ ppm. It clearly indicates that sodium fluoride

containing dentifrice is recharging Fujji II light cure GIC more than sodium monofluorophosphate. The same trend is being followed by other fluoride releasing restorative materials used in the study.

The mean leached out fluoride ion concentration from the F-2000 sample was $3.2 \pm .132$ ppm, when brushed with sodium fluoride containing Pepsodent 2-in-1 dentifrice. While the leached out fluoride ion concentration for F-2000 samples when brushed with sodium monofluorophosphate dentifrice was $2.52 \pm .225$ ppm and for those samples which were brushed with non fluoride containing dentifrice New Close-Up was $1.24 \pm .102$ ppm. The mean fluoride ion concentration for the samples not brushed with any dentifrice was $1.04 \pm .0500$ ppm. It was seen that mean fluoride ion concentration of the specimen brushed with non fluoridated dentifrice is slightly more than specimens not brushed at all. This could be attributed to the fact that brushing abrades the superficial matrix of restorative material and thus releasing more fluoride ion.

Table 2. Mean fluoride ion concentration at various time intervals of all fluoride releasing restorative materials.

	T 1 (Day 1)			T7 (Day 7)			T 14 (Day 14)			T 21 (Day 21)			T 28 (Day 28)		
	M	SD	SE	M	SD	SE	M	SD	SE	M	SD	SE	M	SD	SE
IA	6.35	.2695	.1556	5.02	.1818	.1049	3.99	.0556	.0321	2.02	.0529	.0305	1.62	.0315	.0202
IB	4.52	.1115	.0643	3.99	.0814	.0470	2.03	.0611	.0352	1.21	.0300	.0173	0.92	.0200	.0115
IC	3.53	.1193	.0688	3.22	.0450	.0260	1.06	.0404	.0233	0.64	.0300	.0173	0.54	.0264	.0152
ID	3.0	.0500	.0288	2.98	.0737	.0425	0.90	.0251	.0145	0.57	.0360	.0208	0.48	.0351	.0202
IIA	3.2	.1323	.0763	3.01	.04000	.0230	2.78	.0360	.0208	1.72	.0300	.0173	1.31	.0404	.0233
IIB	2.52	.2255	.1302	2.15	.0568	.0328	1.93	.0200	.0115	1.03	.0400	.0230	0.87	.0351	.0202
IIC	1.24	.1026	.0592	1.17	.0624	.0360	0.78	.0416	.0240	0.27	.0351	.0202	0.22	.0251	.0145
IID	1.04	.0556	.0321	1.02	.0680	.0393	0.61	.0458	.0264	0.21	.0251	.0145	0.15	.0251	.0145
IIIA	1.16	.0702	.0405	1.07	.0611	.0352	0.93	.0208	.0120	0.87	.0493	.0284	0.85	.0351	.0202
IIIB	0.84	.1100	.0635	0.81	.0208	.0120	0.76	.0404	.0233	0.72	.0450	.0260	0.57	.0351	.0202
IIIC	0.55	.1200	.0692	0.51	.1054	.0608	.29	.0737	.0425	0.27	.0200	.0115	0.17	.0152	.0088
IIID	.42	.0709	.0409	.39	.0602	.0348	0.21	.0100	.0577	0.20	.0458	.0264	0.13	.0251	.0145

The mean leached out fluoride ion concentration from the Teethmate F-1, when brushed with sodium fluoride containing Pepsodent 2-in-1 dentifrice was $1.16 \pm .070$ ppm. While the leached out fluoride ion concentration was $0.84 \pm .110$ ppm for Teethmate F-1 samples when brushed with sodium monofluorophosphate dentifrice and $0.55 \pm .1200$ ppm for those samples which were brushed with non fluoride containing dentifrice New Close-Up. The mean fluoride ion concentration for the samples not brushed with any dentifrice was $.42 \pm .071$ ppm.

All restorative materials used in the study showed a Fluoride ion concentration decreased for all the samples from T1 to T28 irrespective of the dentifrice used.

Moreover, there is significant difference in recharging of fluoride ion concentration ($p > .001$) of all fluoride releasing materials when brushed with sodium fluoride containing dentifrice as compared to when brushed with sodium monofluorophosphate containing dentifrice. There is no significant difference ($p > .05$) in fluoride ion concentration release of all material when not brushed

with any dentifrice or brushed with a non fluoridated dentifrice (Figure 5).

Regression line was represented by $y = a + bx$. In which 'b' represented the rate at which the mean concentration of fluoride changed (increased / decreased) with time. 'x' represented the days (time factor) and 'y' represented the fluoride ion concentration (in ppm). The 'b' value was negative for all restorative materials used which supports the observation mentioned above concerning the time bound decrease in fluoride ion concentration of all fluoride releasing restorative materials when either brushed with fluoride containing / non fluoride containing dentifrice or when not brushed at all (Table 3, Figure 6, Figure 7, Figure 8). Table 4 shows analysis of variance for different restorative materials testing for their fluoride release and recharging capacity, when brushed with different dentifrices after 24 hours, 7 days, 14 days, 21 days and 28 days. 'p' value was found to be $< .01$ for all the intergroup and intragroup comparisons indicating a highly significant difference.

The non fluoride releasing pit and fissure sealant Alphadent neither have any potential for fluoride release nor did it show any recharging and subsequent release of fluoride ion when brushed with fluoridated

Table 3 Correlation between time and mean fluoride ion concentration and regression line equation for all fluoride releasing restorative materials

FIJII ILC	Correlation Coefficient'r'	Regression Line $Y = a + bx$
Pepsodent 2-in-1 (IA)	-0.985	$Y = 6.39 + (- 0.18) x$
Colgate Herbal (IB)	- 0.965	$Y = 4.61 + (- 0.15) x$
New Close-Up (IC)	- 0.928	$Y = 3.58 + (- 0.12) x$
Control (ID)	- 0.913	$Y = 3.14 + (- 0.11) x$
COMPOMER F-2000		
Pepsodent 2-in-1 (IIA)	-0.962	$Y = 3.46 + (- 0.07) x$
Colgate Herbal (IIB)	- 0.961	$Y = 2.78 + (- 0.07) x$
New Close-Up (IIC)	- 0.968	$Y = 1.35 + (- 0.04) x$
Control (IID)	- 0.966	$Y = 1.15 + (- 0.04) x$
TEETHMATE F-1		
Pepsodent 2-in-1 (IIIA)	-0.963	$Y = 1.14 + (- 0.01) x$
Colgate Herbal (IIIB)	- 0.948	$Y = 0.87 + (- 0.009) x$
New Close-Up (IIIC)	- 0.979	$Y = 0.59+ (- 0.15) x$
Control (IIID)	- 0.943	$Y = 0.26 + (- 0.004) x$

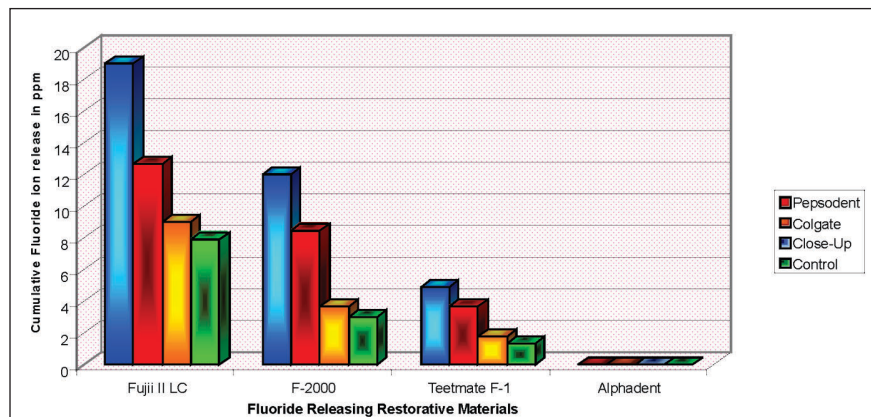


Figure 5: Cumulative Fluoride Release in ppm By Various Restorative Materials In The Stipulated Time Period Of 28 Days

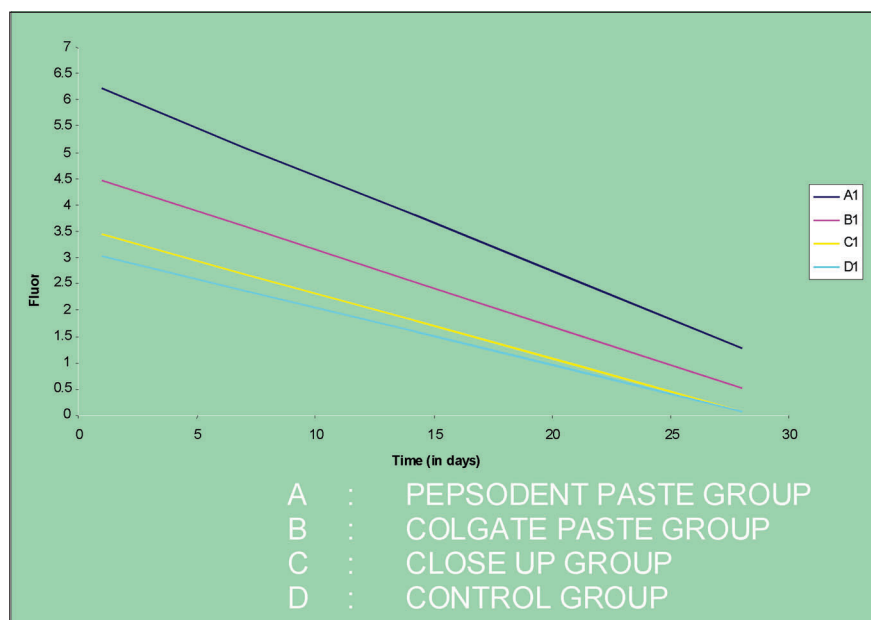


Figure 6: Linear regression lines for resin modified GIC (Fuji II IC)

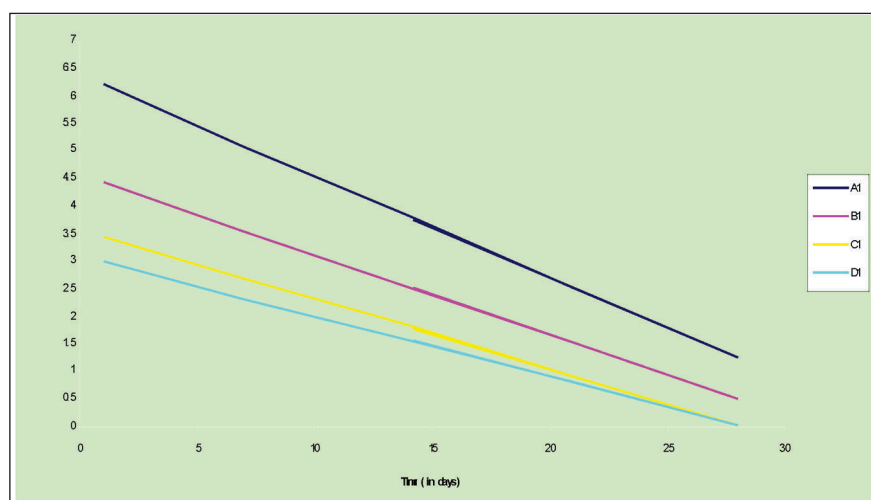


Figure 7: Linear Regression Lines For Compomer (F-2000)

dentifrices thus proving that experiment was done under standard conditions and was giving true results.

DISCUSSION

Dental caries – the decay of tooth, has been one of the commonest occurrences affecting the human population, and has crippled our oral health for generations. It impairs the quality of life for many people causing pain, discomfort and loss of function. In addition, it places a heavy financial burden on patients. Scientific research, technologic advances and a better understanding of the disease process have contributed to dentistry’s emergence from a purely repairable art towards a preventive oriented science. Fluorides play a key role in the prevention of caries. As caries preventive properties of fluorides became more widely demonstrated, it became apparent that fluoride not only prevents dental caries pre-eruptively by systemic incorporation into developing enamel, but also post eruptively by topical action (17). The options available for topical application of fluoride are either professional or at home. Professional application of topical fluorides though effective in caries prevention, relies largely on patient’s compliance. Amongst the home application of topical fluorides, the most convenient is fluoridated dentifrices.

A unique feature of fluoride containing dentifrices, compared to other fluoride compounds, is that they are generally used as a part of normal body hygiene procedures. Surface enamel and plaque are therefore, exposed to fluoride regularly and more or less continuously on a daily basis (18).

So in the present study, sodium fluoride and sodium monofluorophosphate containing dentifrices were used as they are the most widely accepted fluoridated dentifrices in use. Fluoride doesn’t eradicate the dental caries enmass but reduces the incidence and progression of carious lesion, studies indicate that fluoride reduces up to 40% – 60% of carious lesion (18). Therefore, it was thought to incorporate fluoride into the structure of the restorative

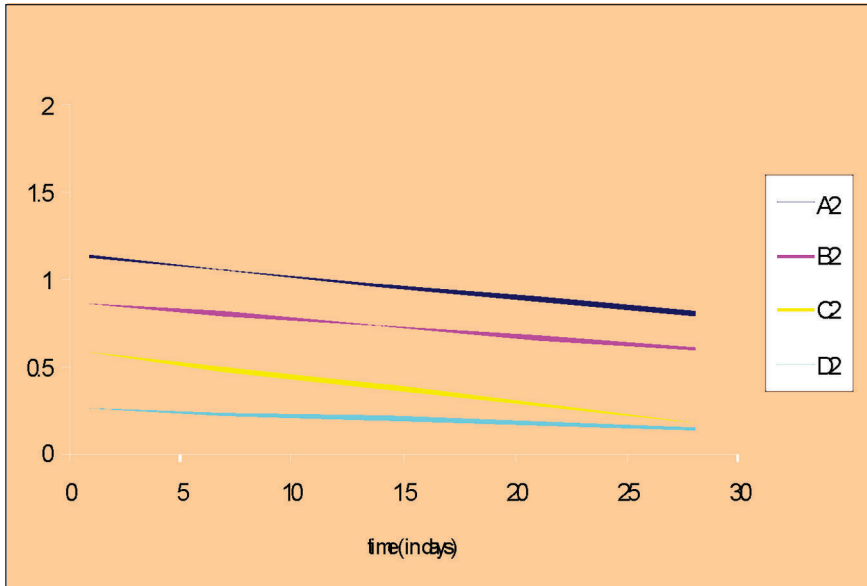


Figure 8: Linear Regression Lines For Fluoride Releasing Pit And Fissure Sealant

material so that it would be caries preventive with the introduction of fluoride releasing dental materials, an option for simultaneously restoring the clinically evident caries along with protection against recurrent caries became available.

But these fluoride releasing materials release fluoride in an initial burst and then reduce exponentially to a much lower steady state level of release in few days (9). If there was only a one way release of fluoride there would be a danger of emptying the fluoride resources after some period of time (10).

Several recent reports have assessed the ability of fluoridated dentifrices to reduce the acid solubility of tooth material and to remineralize incipient lesions both in vitro and in vivo using a variety of parameters including microradiography and polarized light microscopy (19).

Table 4: ANOVA TABLE: Comparison between the different dentifrices (A, B, C and D) vs. different restorative materials (I, II, III)

Group - I	T1 (Day 1)		T7 (Day 7)		T14 (Day 14)		T21 (Day 21)		T28 (Day 28)	
	Between groups	Within groups	Between groups	Within groups	Between groups	Within groups	Between groups	Within groups	Between groups	Within groups
Fuji II LC										
Degree of Freedom	3	8	3	8	3	8	3	8	3	8
Sum of Square	35.665	.204	26.025	.094	9.556	.018	4.698	.011	2.001	.007
Mean Square	11.888	.025	8.675	.011	3.185	.002	1.566	.001	.667	.0008
Significance	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS
Group - II	T1 (Day 1)		T7 (Day 7)		T14 (Day 14)		T21 (Day 21)		T28 (Day 28)	
	Between groups	Within groups	Between groups	Within groups	Between groups	Within groups	Between groups	Within groups	Between groups	Within groups
F-2000										
Degree of Freedom	3	8	3	8	3	8	3	8	3	8
Sum of Square	9.603	.164	8.784	.026	9.379	.011	4.562	.008	2.782	.008
Mean Square	3.201	.020	2.928	.003	3.126	.001	1.521	.001	.927	.001
Significance	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS
Group - III	T1 (Day 1)		T7 (Day 7)		T14 (Day 14)		T21 (Day 21)		T28 (Day 28)	
	Between groups	Within groups	Between groups	Within groups	Between groups	Within groups	Between groups	Within groups	Between groups	Within groups
Teethmate F-1										
Degree of Freedom	3	8	3	8	3	8	3	8	3	8
Sum of Square	1.369	.072	1.200	.037	.926	.015	.997	.013	1.051	.006
Mean Square	.456	.009	.400	.004	.309	.001	.332	.001	.350	.0008
Significance	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS	.000-HS

So, if fluoride from dentifrice can be incorporated into tooth material, it can also get incorporated into fluoride releasing restorative materials and recharge their fluoride ion concentration, as daily tooth brushing with fluoridated dentifrices may replenish material surface level at each brushing interval. Thus, a reservoir of fluoride could be created for constant release and a certain reduction in caries could be evident till restoration is maintained in the oral cavity as concluded by Donly Kevin J (1997) (11).

Hence, in the light of above knowledge, the aim of the present study was to see whether various fluoridated dentifrices recharge fluoride releasing restorative materials and to comparatively evaluate their recharging capabilities.

Among the fluoride releasing restorative materials, resin modified glass ionomer cement (Fuji II light cure), Compomer (F-2000), Fluoridated pit and fissure sealant (Teethmate F1) was used in the present study

A non fluoride releasing pit and fissure sealant was used as a control just to confirm that experiment was done under standard conditions and was giving true results. It further proved that fluoride ion did not get incorporated in experimental setup from sources other than intentional use of fluoridated dentifrices.

All the materials were evaluated for their recharging capabilities with fluoride ions, within 24 hours of their setting and then after 7 days, 14 days, 21 days and 28 days. Pellets of each material were kept in different vials to avoid any physical and chemical contamination of the restorative material. For the whole experimental period, the storage media used was deionized water as it is devoid of any ions, doesn't react with the ions of restorative materials. Reports from the studies of Robertella Francis (1999) (20) suggested that, there are certain variations seen in natural saliva and technical difficulties associated with the use of artificial saliva so deionized water was used in this study to ensure that fluoride release

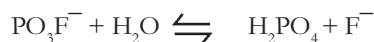
would be unaffected by these variables. Teflon moulds were used in the present study to prepare the experimental pellets as they can be autoclaved and do not react with any material

In the present study, the fluoride ion measurement was done by standard ion selective method as this is the standard method for the examination of the water and waste water as accepted by American Public Health Association, American Water Works Association and Water Environment Federation (21). The instrument used was spectrophotometer (HACH/DR/4000U) which is a highly sensitive fluoride ion digital analyzer. It measures the fluoride ion with the help of infrared rays and appropriate sensors, and is not as technique sensitive as fluoride ion electrode used in other studies

All the findings clearly show that the recharging of fluoride ion was greatest when brushed with sodium fluoride containing dentifrice Pepsodent 2-in-1 followed by sodium monofluorophosphate containing dentifrice Colgate Herbal.

These findings are favoured by the independent studies done regarding the deposition of fluoride in incipient carious lesions which suggested that a greater amount of fluoride deposition was obtained with sodium fluoride dentifrices than with sodium monofluorophosphate dentifrices (19-22)

As Sodium fluoride is an odourless, white solid powder. It is highly soluble in water to the extent of one gram in 25ml. While sodium monofluorophosphate is a stable white powder. Dilute solutions are very stable as the fluoride of this compound is bound covalently with phosphate, and thus, caries inhibiting action of sodium monofluorophosphate is linked to its slow hydrolysis, whereby small concentrations of fluoride are released.



The potential caries preventive effect of the release – adsorption-release of fluoride found in dental materials should be

investigated extensively before substantiating the results obtained from this study.

CONCLUSION

- All restorative materials used in the study showed a fluoride recharging capability when brushed with fluoridated dentifrices.
- Sodium fluoride containing dentifrice recharged fluoride releasing restorative materials more than sodium monofluorophosphate containing dentifrice.
- All materials exhibited a large initial release followed by a gradual decrease in fluoride ion concentration inspite of being brushed with fluoride containing dentifrices regularly.
- Initial fluoride release was found to be maximum and then decreased which could not be restored to the initial level even after brushing with fluoridated dentifrices regularly.
- Resin modified glass ionomer cement released maximum cumulative fluoride compared to other restorative materials tested over 28 day period.
- Fluoride releasing pit and fissure sealant Teethmate F-1 released least cumulative fluoride in comparison to other restorative material tested over 28 day period.
- Thus, the cumulative fluoride release from the restorative materials could be summarized as Fuji II LC > F-2000 > Teethmate F-1

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