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AN INVITRO COMPARATIVE EVALUATION OF FLUORIDE RELEASE FROM DIFFERENT FLUORIDE CONTAINING RESTORATIVE MATERIALS IN VARIOUS STUDY SOLUTIONS

[1] Suman Makam
[2]Mallikarjun Goud

[1]. *Reader,* Department of Conservative Dentistry and Endodontics.
[2] Professor, Department of Conservative Dentistry and Endodontics

[1,] D A Pandu Memorial R V Dental College, J.P.Nagar, Bangalore- 78,Karnataka, India.
[2,] Bapuji Dental College & Hospital, Davangere-577004, Karnataka, India

ABSTRACT

The aim of this study was to determine the level of fluoride released from four different tooth colored restorative materials; Vitremer, Fuji II LC, Dyract and Tetric ceram in three different storage solutions; artificial saliva, De-ionized water and pH cycling system and also to compare the amount of fluoride released. Fifteen discs of each material were prepared in a Teflon mould, varnish applied, polished, then stored at 37^0C and 100% relative humidity for a day. Each storage solution of 2 ml was pipetted into five polypropylene tubes and five samples of each material were suspended individually and the fluoride released was measured using an Orion fluoride Specific Electrode and Digital Ion Analyzer. All the results were statistically analyzed and was concluded that vitremer showed the highest fluoride release followed by Fuji II LC, Dyract and Tetric Ceram in the pH cycling system followed by De-ionized water and least in Artificial saliva.

KEY WORDS:. Artificial saliva,Deionised water,Fluoride release,Ion electrode.

INTRODUCTION

The observation of low incidence of secondary caries around fluoride containing restorations have encouraged the incorporation of fluoride as an additive or fusing agent, into restorative materials[1]. As far as the field of dentistry is concerned, the discovery of fluorides represents an epoch making event.

The metabolic products of the dental plaque bacteria, including lactic, acetic and citric acid, reduces pH of the oral environment, demineralizing the dental hard tissues. Any mechanism that inhibits the acid production from the dental plaque bacteria increases the resistance to demineralization and / or facilitates remineralization. The antimicrobial activity of fluoride is one such mechanism[2]. The restorative materials that release fluoride prevents secondary caries and hence are of considerable clinical interest.

Currently two widely used tooth colored restorative materials – compomers and resin reinforced glass ionomers have provided proven fluoride release with a potential cariostatic activity. However, in recent years, the fluoride releasing composites have become popular restorative materials.

The cavitation of the dental hard tissues occur as a result of imbalance between the demineralization & remineralization cycle occurring in the oral cavity and the pH cycling system is an exact analog of this cycle[3].

So far the in-vitro fluoride release of the dental materials were checked in solutions that did not simulate the caries process. Hence this study determines the level of fluoride released from different fluoride containing restorative materials in new study solutions[3].

Aims

The aim of the present study was:

1. To determine the level of fluoride released from four different tooth coloured restorative materials in different storage solutions.
2. To compare the amount of fluoride released from Vitremer, Fuji II LC, Dyract and Tetric ceram restorative materials in different storage solutions for a period of 21 days.

Materials and Methods

Materials

1. Vitremer (3M) - Tri cure resin modified glass ionomer restorative material.
2. Dyract (Dentsply) - compomer restorative material
3. Fuji II LC (GC Fuji) - Dual cure resin modified glass ionomer restorative material.
4. Tetric ceram (Ivoclar) - fluoride releasing composite restorative.

Storage Solutions

1. pH cycling system (Demineralizing-Remineralizing solution)
2. De-ionized water
3. Artificial saliva

The sample size consisted of 15 discs of each test material, out of which 5 discs were used for each of the 3 different experimental solutions. The test materials were mixed and cured according to the manufacturer's instructions and placed in the Teflon mold of size 8.6 mm diameter and 1.65 mm depth. During the setting, paraffin dental floss was incorporated into the test material, which helped to suspend the samples in the test medium.

A glass plate was used to cover the open end of the Teflon mold. Cavity varnish was applied to the discs and the excess material was removed and polished using 3M soflex discs, which were then stored at 37^0C and 100% relative humidity for a day.

The samples were divided into following groups:

- Group D_1 – Consisting of 15 discs of Vitremer material.
- Group D_2 – Consisting of 15 discs of Dyract material.
- Group D_3 – Consisting of 15 discs of Fuji II LC material
- GroupD_4 - Consisting of 15 dics of Tetric ceram material

These specimens were immersed in the following study solutions.

- Group S_1 - pH cycling system (De- Re solution)
- Group S_2 – De - Ionized water
- Group S_3 – Artificial saliva

2 ml of each storage solution was pipetted into the 5 polypropylene tubes and 5 samples of each of these materials were suspended individually in each of the above study solutions.

Once in a day, De – ionized water and Artificial saliva were changed, where as the specimens in the pH cycling system were immersed for the first 6 hours in demineralizing solution (pH 4.3) and then shifted to a remineralizing solution (pH 7.0) for the next 18 hours. This cycle continued for 21 days.

At the end of each day, the discs were removed from the solution, kept in test tubes and TISAB solution was then added to these individual test tubes to measured the total amount of fluoride ion concentration available, which was then measured and recorded using an orion fluoride ion electrode and orion digital ion analyzer.

Results

The results were analyzed statistically by a two way ANOVA for interaction effects in both materials and media.

The fluoride released by the various test materials in each experimental solution were compared by one-way ANOVA followed by pairwise comparison using Newman - Keul's test.

The average fluoride released from each of the 5 discs of each restorative material in different solutions at the end of 21 days is shown in **Table 1.**

1. Vitremer, Fuji II LC, Dyract, Tetric Ceram discs at the end of 21 days showed the highest fluoride release in De-Re solution followed by De-ionized water and least in artificial saliva.

2. To compare the amount of fluoride released between the materials in each study solution a one way ANOVA method was employed showing the following results.

   i) The mean fluoride released by the restorative materials in the De-Re solution shows that Vitremer showed the highest fluoride release followed by Fuji II LC, Dyract and the least was that released by Tetric ceram as shown in **Table 2.**
   ii) The mean fluoride released by the restorative materials in the Deionized water shows that Vitremer showed the highest fluoride release followed by Fuji II LC, Dyract and the least was that released by Tetric ceram as shown in **Table 3.**
   iii) The mean fluoride released by the restorative materials in the artificial saliva shows that Vitremer showed the highest fluoride release followed by Fuji II LC, Dyract and the least was that released by Tetric ceram as shown in **Table 4**.

Discussion

The fluoride ions inhibit the enzymatic production of glucosyl transferase thus preventing the glucose from forming extra cellular polysaccharides, reducing the bacterial adhesion and slowing down the ecological succession[4]. The intracellular polysaccharide formation is also inhibited thus preventing the storage of carbohydrates by limiting the microbial metabolism between the host meals[5].

The fluoride release was estimated because secondary or recurrent caries has been one of the primary causes for the failure of dental restorations and low frequency of secondary caries around GIC restorations is mainly due to the fluoride release from the cement and uptake by the dental hard tissues[3].

The analysis of fluoride released was checked every day for 21 days with the help of Orion Fluoride ion electrode and Orion Digital Ion analyzer.

Table.1. Average fluoride release (ppm) by the various restorative materials in different storage solutions

	VITREMER Group- D1			DYRACT Group-D2			FUJI II LC Group-D3			TETRIC CERAM Group- D4		
DISCS	DE-RE	WATER	AS	DE-RE	WATER	AS	DE-RE	WATER	AS	DE-RE	WATER	AS
1	11.95	9.44	3.81	8.31	2.65	2.1	10.64	5.84	2.88	3.57	2.1	2.03
2	12.87	8.96	3.03	8.95	2.41	1.97	11.38	6.07	2.57	3.81	1.86	2.14
3	12.96	9.93	4.69	9.03	2.36	2.04	11.21	6.13	2.63	3.84	2.37	1.96
4	13.04	10.04	4.52	8.83	2.17	2.17	10.04	5.71	3.05	3.16	2.31	1.92
5	10.35	8.87	3.48	7.91	2.02	2.68	9.72	6.02	3.11	3.25	1.92	2.08
MEAN	12.23	9.45	3.91	8.61	2.45	2.06	10.06	5.95	2.85	3.53	2.11	2.03
SD	1.14	0.54	0.7	0.48	0.21	0.08	0.72	0.17	0.24	0.31	0.23	0.09
SEM	0.51	0.24	0.31	0.21	0.1	0.03	0.32	0.08	0.11	0.14	0.1	0.04

DE-RE: Demineralizing Remineralizing Solution; AS: Artificial Saliva. SD: Standard Deviation.SEM: Standard Error of Mean.

Table.2. **Comparison of fluoride release (ppm) between the restorative materials in DE-RE Storage Solution**

Materials	Mean SE	I	II	III	IV
Vitremer	12.23±0.51	-	P<0.01	P<0.01	P<0.01
Dyract	8.61±0.21	-	-	P<0.01	NS
FujiII LC	10.6±0.32	-	-	-	P<0.01
Tetric-Ceram	3.21±0.31	-	-	-	-

One factor ANOVA (F-102.5; P<0.01) Ve=0.63; Newman-Keuls range test ;
LSD-Least Significant Difference= 1.84ppm (P<0.01, Significant)
F- ANOVA F-test; SE- Standard Error.;P- Probability.

Table.3. Comparison of fluoride release (ppm) between the restorative materials in De-ionized water Storage Solution

Materials	Mean SE	I	II	III	IV
Vitremer	9.45±0.24	-	P<0.01	P<0.01	P<0.01
Dyract	2.45±0.10	-	-	P<0.01	NS
FujiII LC	5.95±0.08	-	-	-	P<0.05
Tetric-Ceram	2.11±0.10	-	-	-	-

One factor ANOVA (F-569.3; P<0.01) Ve=0.10; Newman-Keuls range test
LSD 0.57 P<0.05; 0.73 P<0.01; LSD-Least Standard Deviation

In this study the ion selective method in conjunction with TISAB was used so that the estimate of the fluoride ions will be as accurate as possible, because TISAB preferentially decomplexes fluoride polyvalent cations therefore making fluoride available for measurement[6].

The fluoride released by all the materials was highest during the first 24 hrs and decreased sharply over the first week[3,7,8,9] and then stabilized during the test period.

The release of fluoride from the glass ionomer cements varies with the various factors, intrinsic and extrinsic [10]. The intrinsic factors are related to the preparation of the material; its powder: liquid ratio, mixing time, specimen geometry, surface protection and finish and permeability of the material[11].
The extrinsic factors are related to the storage and dissolution medium (pH, temperature, composition), experimental design (volume of storage solution, frequency and solution change and stirring) and analytic method[11].
The manipulation of the materials and the type of fluoride incorporated during the manufacturing affects the rate of fluoride release as it depends on the formation of the complex fluorides and their interaction with the polyacrylic acid and the type of amount of resin used for the photo chemical polymerization reaction[6].

A glass with a high concentration of fluoride used in the construction of the glass ionomer would be expected to release more fluoride than the one with a lower concentration[12].

The fluoride release is a pH controlled process and lower pH (demineralizing solution pH 4.3) resulted in greater release of fluoride [3]. The least amount of fluoride was released in artificial saliva because of the presence of cations and an- ions in artificial saliva, with an ionic affect on their solubility [6,11].

A possible explanation for the greater fluoride release in resin modified glass ionomers (Vitremer and Fuji II LC) could be due to the absorption of sufficient water by poly-HEMA thereby enabling better diffusion of the fluoride ions which may otherwise be firmly encapsulated in the poly acrylate matrix[12]. Vitremer showed greater fluoride release when compared with Fuji II LC because of a lower Powder: Liquid ratio in vitremer thereby releasing more amount of fluoride in DE-RE solution; followed by De-ionized water and Artificial saliva solution[13].

Dyract showed lesser amount of fluoride release because of its reduced glass ionomer composition as compared to vitremer, and Fuji II LC [14]. The least amount of fluoride release was exhibited by Tetric Ceram as the monomer matrix occupies 20.2% weight and hence more of the fluoride released is encapsulated in this monomer matrix [15].

CONCLUSION

1. Fluoride was released by all the 4 materials in varying concentrations.
2. Vitremer showed the highest fluoride release followed by Fuji II LC; Dyract and Tetric Ceram.
3. The highest fluoride release was measured in the pH cycling system, followed by De-ionized water and least in artificial saliva.
4. The resin modified glass ionomers showed more fluoride release than the compomers.
5. The compomers showed more fluoride release than the composites.
6. Direct correlation was observed between the fluoride release and the pH of the solution.
7. Fluoride release was indirectly related to the Powder: Liquid ratio.

Vitremer showed the highest fluoride release under the conditions of the present study, however before they are used in the clinical situations further in vivo studies are required to prove their efficacy.

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Corresponding Author

Dr. Suman Makam,
Department of Conservative Dentistry & Endodontics,
D A Pandu Memorial R V Dental College,
J.P.Nagar, Bangalore- 78,
Karnataka, India.
Ph: 9845122502, 080 22445754.
E-mail.: sumanmakam@yahoo.com