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Fluoride Release and Uptake of Five Dental Restoratives from Mouthwashes and Dentifrices

B Saketh Rama Rao[1], Gopi Krishna Reddy Moosani[2], Muthu Shanmugaraj[3], Balamurugan Kannapan[4], B. Shiva Shankar[5], Prabu Mahin Syed Ismail[6]

Contributors:

[1]Professor, Department of Conservative Dentistry & Endodontics, Hi-Tech Dental College, Bhubaneswar, Odisha, India; [2]Reader, Department of Conservative Dentistry & Endodontics, G Pulla Reddy Dental College & Hospital, Kurnool, Andhra Pradesh, India; [3]Reader, Department of Conservative Dentistry & Endodontics,, Mar Baselios Dental College, Kothamangal, Kerala, India; [4]Reader, Department of Conservative Dentistry & Endodontics, GSL Dental College & Hospital, Rajamundry, Andhrapradesh, India; [5]Associate Professor, Department of Periodontology & Implantology, G Pulla Reddy Dental College, Kurnool, Andhrapradesh, India; [6]Senior Lecturer, Department of Conservative Dentistry & Endodontics, IBN Sina National College for Medical Studies, Jeddah, Saudi Arabia.

Correspondence:

Dr. Shankar BS. Associate Professor, Department of Periodontology & Implantology, G Pulla Reddy Dental College, Kurnool, Andhrapradesh, India. Email: periopal@gmail.com

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Abstract:

Background: This study evaluated the fluoride release and uptake of five common dental restoratives mainly glass ionomer formulations, including a conventional glass ionomer, a relatively new caries stabilization glass ionomer and resin-modified glass ionomer (Fuji II, Fuji VII and Fuji II LC); one compomer (F2000); and one fluoride releasing composite resin (tetric ceram).

Materials and Methods: A total of 12 cylindrical specimens for each of the five materials were prepared following manufacturer's instructions for manipulation and immersed independently in 25 ml of artificial saliva and stored as five groups Group I-V. Each group was further divided into three sub Groups A, B, C. The saliva was changed every day in all the specimens. No treatment was carried out for the specimens in subgroup A. The specimens were immersed in 2% sodium fluoride for 1 min before changing saliva in sub group B and the specimens were treated by brushing with a fluoridated dentifrice for 2 min before changing saliva in sub Group C. The fluoride release was evaluated on the 1st, 7th and 28th day using a fluoride ion specific electrode.

Results: The results demonstrated that the conventional glass ionomer and the recently introduced caries stabilizing glass ionomer showed similar patterns and quantity of fluoride release, which was significantly higher than the resin-modified glass ionomer, the compomer and the composite resin. The resin-modified glass ionomer showed higher fluoride release than the compomer and the composite resin. All the formulations of glass ionomers showed fluoride uptake from the neutral sodium fluoride and the fluoridated dentifrice, by releasing increased amounts of fluoride after treatment, in comparison with the untreated group. However, the compomer and the composite resin showed no fluoride uptake.

Conclusion: The fluoride released by the glass ionomer cements (GICs) was found to be highest during the first 24 h and decreased significantly over the 1st week with lower levels obtained on the 7th and 28th day, thus demonstrating the phenomenon of "initial burst." The composite resin and compomer used in this study did not show this phenomenon of the initial burst. The resin-modified GICs released more fluoride than the compomer, and the composite resin.

Key Words: Compomer, composite resin, fluoride release, glass ionomer

Introduction

"As, for a long time, iron was given for the blood, calcium and phosphorous for the bones, so has it been successful to add fluoride to the tooth enamel in a soluble and absorbable form. It is fluoride that gives hardness and durability to the tooth and protects it against caries." Erhad`t 1874.[1]

It is a well-established fact that the incidence and severity of secondary caries are reduced around restorations that release fluoride. The leached fluoride acts as a topical application to increase the fluoride content of the surrounding tooth structure, thereby minimizing caries by forming fluorapatite crystals, which are more resistant to acid attack.[2,3]

Since the introduction of silicate cements several decades ago, it was noted that secondary caries around silicate cements was significantly reduced, and this reduction was attributable to the substantial fluoride release generated by this restorative material.[4-6] The glass ionomers, which evolved from silicates have the potential to increase the tooth's resistance to secondary caries due to fluoride release and this has been the hallmark of the material's massive clinical success along with its chemical adhesion to tooth structure.[7]

Studies have also shown that glass ionomers take up fluorides, which are lost from leaching in the oral environment and release it again in a dynamic process, thereby enabling the material to be looked upon as a "re-chargeable slow-release fluoride system." The presence of fluoride in the oral environment thus guarantees long-term fluoride release, from these restorations in the oral cavity the fluoride binds chemically to the glass ionomer and it gradually releases it, and a continuous release uptake process thereby occurs.[8-11] Two big disadvantages of the conventional glass ionomer cement (GIC) are its opaqueness that give it poor

esthetics and poor edge strength. Hence, modifications of GICs are being introduced to overcome the deficiency. Some of the modifications are the resin-modified GICs, compomer, Type VII, IX GP. Attempts are also being made to produce fluoride releasing composites. There are concurring and non-concurring reports about the anticariogenic effect of fluoride, quantity of fluoride released and the type of fluoride released from GICs, resin-modified GIC and fluoride-releasing resin composites.

Considering the importance of fluoride release and the significant role it plays in caries resistance and reducing its progression, the following study was conducted to evaluate the fluoride release and uptake from different formulations of GIC, a compomer and a composite resin, which claim optimum fluoride release.

Materials and Methods

Twelve specimens were made for each of the following five materials and were grouped as Group I - Conventional glass ionomer (Fuji II) (GC Corporation, Tokyo, Japan) Group II - Command set glass ionomer (Fuji VII) (GC Corporation, Tokyo, Japan) Group III - Resin modified glass ionomer (Fuji II LC) (GC Corporation, Tokyo, Japan) Group IV - Compomer (F2000) (3M Dental, 3M center I275-2SE-03, STPaul, MN 55144) Group V - Composite resin (Tetric Ceram) (Ivoclar North America 175 Pine view Dr. Amherst, NY 14228).

Preparation of specimens

All materials were handled according to manufacturer's instructions. After mixing, the materials were placed in a plastic mold of 10 mm diameter and 2 mm height. These specimens were covered with a plastic sheet on both sides and placed between two glass plates. The conventional (Group I) and caries stabilization (Group II) glass ionomers were allowed to set chemically for 10 min before placing them in artificial saliva. Group III, IV and V specimens were light-cured for 40 s each after placing them in the molds. The specimens were then transferred to 60 plastic containers containing 25 ml of artificial saliva.

Preparation of artificial saliva

Artificial saliva was prepared by adding 0.111 g (equivalent to 1 mM) of calcium chloride, sodium dihydrogen phosphate 0.156 g (equivalent to 1 mM), sodium chloride 2.05 g (equivalent to 35 mM), sodium acetate 2.05 g (equivalent to 15 mM) to 1000 ml of de-ionized water. The pH was adjusted to seven by adding potassium hydroxide.[12] The specimens in each of the five groups were subdivided into three subgroups A, B, C. The discs in sub-group A were immersed in artificial saliva for 28 days, and the saliva was changed every day. The discs in sub-group B were immersed in artificial saliva for 28 days and the saliva was changed every day, but specimens were placed in 2% sodium fluoride for 1 min and rinsed with de-ionized water before placing in fresh artificial saliva. The discs in sub-group C were immersed in artificial saliva for 28 days and saliva was changed every day, but specimens were brushed for 2 min every day with a fluoridated dentifrice and rinsed with de-ionized water before placing in fresh artificial saliva.

Fluoride ion evaluation

Fluoride ion measurement was done using a combination of fluoride ion electrode (9609 BN Orion Research, Inc., Beverely, MAO 1915-6199) coupled to a microprocessor ion analyzer (EA 940 Orion Analyzer, Orion research). 10 ml of saliva was mixed with 10% by volume of total ionic strength adjustment buffer (TISAB) to provide a constant background ionic strength and to de-complex the fluoride. The TISAB contains 2% cyclohexyline dinitrilotetracetic acid, a metal chelating agent that partially decomposes fluoride from polyvalent cations, therefore, making fluoride available for measurement. The fluoride calibration slope was checked using standard solutions between 0.1 ppm and 10 ppm fluoride. Before making the measurements, three more specimens of artificial saliva were tested to find the base line concentration of fluoride in the saliva used. These mean baseline concentrations were subtracted from each of the values obtained. The fluoride measurement was evaluated on the 1st day, 7th day, and the 28th day.

Results

Mean and standard deviation of fluoride release were estimated from the sample for each sub group in all the groups on day 1. Statistical analysis by one-way ANOVA, followed by multiple range test by Tukey honestly significant difference (HSD) procedure showed that there is no significant difference in mean values between sub groups A (Table 1), B (Table 2) and C (Table 3) at day-l ($P = 0.91$). At day 7 in Groups I (Table 1), II (Table 2) and III (Table 3) it was found that the mean values in all the sub groups were significantly lower than on the 1st day though the values in sub group B were significantly higher than the mean value in sub group A and in sub group C. Furthermore, the mean value in sub group C was significantly higher than the mean value in sub group A. However there were no significant differences between values in sub groups of Groups IV (Table 4) and V (Table 5). Similar observations were made when comparing values of the 28th day. Statistical analysis by one-way ANOVA, followed by multiple range test by Tukey-HSD procedure showed that the mean value in Group II (Table 2) and Group I (Table 1) are significantly higher than the mean value in Group III (Table 3), Group IV (Table 4) and Group V (Table 5). Furthermore, the mean value in Group III (Table 3) is significantly higher than the mean values in Group IV (Table 4) and Group V (Table 5). However, there was no significant difference in values between Group IV (Table 4) and Group V (Table 5).

Discussion

Fluoride contributes to caries inhibition in the oral environment by means of both physicochemical and

Table 1: Group I fluoride release in µg/cm².

	Sub group A			Sub group B			Sub group C		
	Day 1	Day 7	Day 28	Day 1	Day 7	Day 28	Day 1	Day 7	Day 28
1	79.6	10.35	2.5	71.65	25.02	2.84	76.2	19.33	2.84
2	84.16	9.09	2.16	95.54	26.16	2.72	96.67	13.64	2.61
3	88.71	9.21	3.18	85.3	29.57	2.95	78.48	19.33	2.38
4	81.89	8.07	2.27	89.85	31.84	2.72	93.26	21.61	2.95
Mean	83.59	9.18	7.27	85.58	28.14	18.19	86.15	18.47	11.39

Table 2: Group II fluoride release in µg/cm².

	Sub group A			Sub group B			Sub group C		
	Day 1	Day 7	Day 28	Day 1	Day 7	Day 28	Day 1	Day 7	Day 28
1	87.57	10.35	8.18	101.22	30.7	19.33	94.4	17.06	12.51
2	95.54	11.03	8.87	87.57	29.57	21.61	96.67	20.47	11.37
3	87.57	11.6	8.64	85.3	43.22	20.47	93.26	19.33	15.92
4	95.54	12.65	8.41	89.85	31.84	20.47	89.85	20.47	14.78
Mean	91.55	11.4	8.52	91.55	11.4	8.52	93.54	19.33	13.64

Table 3: Group III fluoride release in µg/cm².

	Sub group A			Sub group B			Sub group C		
	Day 1	Day 7	Day 28	Day 1	Day 7	Day 28	Day 1	Day 7	Day 28
1	3.52	3.52	2.38	3.86	3.86	2.72	3.86	3.86	2.72
2	3.86	3.29	3.29	4.2	3.57	3.29	4.2	3.57	3.29
3	3.75	4.32	3.18	3.98	3.86	2.72	3.98	3.86	2.72
4	3.63	4.2	3.07	4.32	4.32	3.18	4.32	4.32	3.18
Mean	3.69	3.83	2.98	4.09	3.9	2.97	4.09	3.9	2.97

Table 4: Group IV fluoride release in µg/cm².

	Sub group A			Sub group B			Sub group C		
	Day 1	Day 7	Day 28	Day 1	Day 7	Day 28	Day 1	Day 7	Day 28
1	59.14	5	5	54.59	13.64	11.37	40.94	12.51	10
2	47.77	3.5	4.66	58	15.92	14.78	48.9	15.92	8.87
3	46.63	6.71	5	47.77	19.33	12.51	45.49	14.78	9.21
4	44.35	5.34	4.89	36.39	18.19	13.64	52.32	11.37	8.98
Mean	49.47	5.13	4.88	49.18	16.77	10.57	46.91	13.64	9.26

Table 5: Group V fluoride release in µg/cm².

	Sub group A			Sub group B			Sub group C		
	Day 1	Day 7	Day 28	Day 1	Day 7	Day 28	Day 1	Day 7	Day 28
1	2.84	3.29	2.5	3.52	2.72	2.84	3.18	2.72	2.84
2	3.63	2.84	2.16	3.75	3.86	2.72	3.29	2.5	2.61
3	3.29	3.18	3.18	3.18	2.84	2.95	3.86	3.07	2.38
4	3.86	2.27	2.27	2.84	3.18	2.72	3.18	3.29	2.95
Mean	3.4	2.89	2.52	3.32	3.15	2.8	3.37	2.89	2.69

biological mechanisms. Inhibit the enzymatic production of glucosyl transferase, which prevents the glucose from forming extracellular polysaccharides and reduces bacterial adhesion and slows down the ecological succession. The intracellular polysaccharide formation is also inhibited, thus preventing the storage of carbohydrates by limiting the microbial metabolism between the host meals.[1]

Fluoride inhibits the demineralization through the formation of fluorapatite and enhances the remineralization of carious, non-cavitated enamel and biologic mechanisms include inhibition of carbohydrate metabolism by acidogenic plaque microflora. The fluoride enters the microorganisms against a concentration gradient and accumulates intracellularly. The extra cellular pH decreases the transport of hydrogen fluoride into cells leads to dissociation of hydrogen fluoride into H^+ and F^- in the alkaline cytoplasm. Thus, the ionic fluoride inhibits the acid production.[13]

Research has shown that as compared to any other caries preventive material glass ionomer releases more fluoride. The fluoride released by the GICs was found to be highest during the first 24 h and decreased significantly over the 1st week with lower levels obtained on the 7th and 28th day, thus

demonstrating the phenomenon of "initial burst." These results are in agreement with earlier studies.[7,9,14,15] The composite resin and compomer used in this study did not show this phenomenon of the initial burst. This is in agreement with earlier studies where other compomer products (dyract) and composite resins (Tetriceram and Heliomolar) were studied.[16,17] This is also in contrast with some studies where the compomer (dyract) and a composite resin (fluorever) showed high initial fluoride release.[18,19]

There was no significant difference in fluoride release between the conventional glass ionomer and the new command set glass ionomer. These cements released significantly more fluoride initially than the resin-modified glass ionomer, the compomer and the composite resin.

In conventional cements, the fluoride release rate depends on the formation of complex fluorides with the interaction with polyacrylic acid. Resin modified glass ionomers were mostly found to have a potential for fluoride release in equivalent amounts as conventional cements, but may be affected not only by the formation of complex fluoride compounds and their interaction, but also the type and amount of resin used for the photochemical polymerization reaction.[20]

Type VII material is a glass ionomer without inclusion of resins. The pink shade of the cement allows for the absorption of energy from a visible light curing unit. This accelerates the setting of the cement and provides for early protection against de-hydration. The low viscosity, combined with levels of fluoride release equivalent to that of conventional glass ionomers, and a translucent pink shade offers visible control during recall visits.

In Fuji II LC, the light activated GICs is the hydrophilic poly-hydroxyethyl methacrylate probably absorbs sufficient water to enable diffusion of fluoride ions that may otherwise be firmly encapsulated within the polyacrylate matrix. It is also assumed and is also evident from our study that, in the set material of resin-modified GIC, fluoride ions might be firmly encapsulated by the resin matrix and consequently its fluoride release rate into an aqueous environment might be lower and slower than that of conventional GICs.[20]

The resin-modified GIC released more fluoride than the compomer, and a composite resin which is in agreement with various studies.[21-23] Composite resins are made of synthetic resin in which case, fluoride ions might be firmly encapsulated by the resin matrix and consequently its fluoride release rate into an aqueous environment might be smaller and slower than that of conventional GICs.[20]

In vitro studies have shown that fluoride released from fluoride-containing restorative materials effectively protected the enamel from demineralization in the region near to the restorative materials.[24] Glass ionomer have been shown to be recharged from topical fluoride applications. Fluoride rinses, varnish gels, are being used as topical fluoride agents, which act as storehouse for fluoride ions.[25-27] Studies using an electron probe microanalysis technique have confirmed the transfer of strontium and fluoride ions into the dentine from GICs.[28]

Since fluoride release varies with the type of glass ionomer, the fluoride uptake will be dependent on the cement, and available fluoride type.[29] GICs can release the greatest amount of fluoride among currently available dental restorative materials. This is attributed to their acid–base reaction that can subsequently result in the leaching of fluoride.[30] Therefore this study was conducted to measure the fluoride uptake of glass ionomers, compomer and a composite resin and its subsequent re-release, after exposure to neutral sodium fluoride and commercially available fluoride toothpaste, using the daily brushing regimen of 2 min. The study shows that the fluoride had diffused into the matrix material of the GICs, increasing its reservoir of fluoride, from which it is subsequently and slowly leached. Hence, this finding illustrates that the additional release was not a result of only a wash out of fluoride ions adsorbed to the surface of cement, but also due to the diffusion into the matrix.[31,32]

In vitro results may not be directly representative of *in vivo* results. Fluoride release was measured from specimens immersed in a static medium, and that may not take into account the dynamic nature of conditions in the oral cavity.

Conclusion

Carious tooth destruction results from episodes of demineralization of tooth structure exceeding remineralization over time. Consequently, to optimize the possibility for recurrent caries inhibition, a sustained level of fluoride release over time from a restorative material-adhesive system is necessary. Since the intrinsic fluoride release from fluoridated restorative materials and adhesives declines with time, the capacity for a restoration to exhibit anticarious activity will be determined by the material's ability to demonstrate fluoride recharge also.

References

1. Murray JJ, Rugg Gunn AJ, Jenkins GN. Fluorides in Caries Prevention, 3rd ed. Mumbai: Varghese Publishers; 1991.
2. Anusavice KJ. Phillip's Science of Dental Materials, 10th ed. USA: W.B Saunders Company; 1996.
3. Perrin C, Persin M, Sarrazin J. A comparison of fluoride release from four glass-ionomer cements. Quintessence Int 1994;25(9):603-8.
4. Sidney FB. Clinical Pedodontics, 4th ed. USA: W.B Saunder Company; 1995.
5. Christensen GJ. Compomers vs. resin-reinforced glass ionomers. J Am Dent Assoc 1997;128(4):479-80.

6. Cooley RL, Sandoval VA, Barnwell SE. Fluoride release and color stability of a fluoride-containing composite resin. Quintessence Int 1988;19(12):899-904.
7. el Mallakh BF, Sarkar NK. Fluoride release from glass-ionomer cements in de-ionized water and artificial saliva. Dent Mater 1990;6(2):118-22.
8. Diaz-Arnold AM, Holmes DC, Wistrom DW, Swift EJ Jr. Short-term fluoride release/uptake of glass ionomer restoratives. Dent Mater 1995;11(2):96-101.
9. Creanor SL, Carruthers LM, Saunders WP, Strang R, Foye RH. Fluoride uptake and release characteristics of glass ionomer cements. Caries Res 1994;28(5):322-8.
10. Freedman R, Diefenderfer KE. Effects of daily fluoride exposures on fluoride release by glass ionomer-based restoratives. Oper Dent 2003;28(2):178-85.
11. Forsten L. Short- and long-term fluoride release from glass ionomers and other fluoride-containing filling materials *in vitro*. Scand J Dent Res 1990;98(2):179-85.
12. Karantakis P, Helvatjoglou-Antoniades M, Theodoridou-Pahini S, Papadogiannis Y. Fluoride release from three glass ionomers, a compomer, and a composite resin in water, artificial saliva, and lactic acid. Oper Dent 2000;25(1):20-5.
13. Ekstrand J, Fejerskov O, Silverstone LM. Fluoride in Dentistry, 1st ed. Copenhagen: Munksgaard; 1988.
14. Derkson GD, Poon PJ, Richardson AS. Fluoride release from a silicophosphate cement with added fluoride. J Dent Res 1982;61(5):660-4.
15. Hörsted-Bindslev P, Larsen MJ. Release of fluoride from conventional and metal-reinforced glass-ionomer cements 1990;98(5):451-5.
16. Lammers PC, Borggreven JM, Driessens FC, van 't Hof MA. Acid-susceptibility of lesions in bovine enamel after remineralization in the presence of fluoride and/or carbonate. Caries Res 1992;26(1):1-7.
17. Swartz ML, Phillips RW, Clark HE. Long-term F release from glass ionomer cements. J Dent Res 1984;63(2):158-60.
18. Temin SC, Csuros Z. Long-term fluoride release from a composite restorative. Dent Mater 1988;4(4):184-6.
19. Eliades G, Kakaboura A, Palaghias G. Acid-base reaction and fluoride release profiles in visible light-cured polyacid-modified composite restoratives (compomers). Dent Mater 1998;14(1):57-63.
20. Momoi Y, McCabe JF. Fluoride release from light-activated glass ionomer restorative cements. Dent Mater 1993;9(3):151-4.
21. Forsten L. Resin-modified glass ionomer cements: Fluoride release and uptake. Acta Odontol Scand 1995;53(4):222-5.
22. Mazzaoui SA, Burrow MF, Tyas MJ. Fluoride release from glass ionomer cements and resin composites coated with a dentin adhesive. Dent Mater 2000;16(3):166-71.
23. Bertacchini SM, Abate PF, Blank A, Baglieto MF, Macchi RL. Solubility and fluoride release in ionomers and compomers. Quintessence Int 1999;30(3):193-7.
24. Hegde MN, Shetty AV. Fluoride release from three different glass ionomer cements in de-ionised water - An *in vitro* study. Univers J Pharm 2013;2(6):47-51.
25. Dionysopoulos D, Koliniotou-Koumpia E, Helvatzoglou-Antoniades M, Kotsanos N. Fluoride release and recharge abilities of contemporary fluoride-containing restorative materials and dental adhesives. Dent Mater J 2013;32(2):296-304.
26. Yaman SD, Er O, Yetmez M, Karabay GA. *In vitro* inhibition of caries-like lesions with fluoride-releasing materials. J Oral Sci 2004;46(1):45-50.
27. Kerolina M. Fluoride release of resin modified GIC versus fluoride containing composite resin – A quantitative systematic review. J Minimum Interv Dent 2010;3(2):30-52.
28. Wang YL, Lee BS, Chang KC, Chiu HC, Lin FH, Lin CP. Characterization, fluoride release and recharge properties of polymer – Kaolinite nanocomposite resins. Compos Sci Technol 2007;67(15-16):3409-16.
29. Mousavinasab SM, Meyers I. Fluoride release and uptake by glass ionomer cements, compomers and giomers. Res J Biol Sci 2009;4(5):609-16.
30. Hegde MN, Susan JJ, Darshana D, Hegde ND. Effect of daily fluoride exposure on fluoride release by high strength glass ionomer restorative material used with ART - An *in vitro* study. Int Res J Pharm 2012;3(4):241-6.
31. Knight GM, McIntyre JM, Craig GG, Mulyani. Ion uptake into demineralized dentine from glass ionomer cement following pretreatment with silver fluoride and potassium iodide. Aust Dent J 2006;51(3):237-41.
32. Naoum S, O'Regan J, Ellakwa A, Benkhart R, Swain M, Martin E. The effect of repeated fluoride recharge and storage media on bond durability of fluoride rechargeable Giomer bonding agent. Aust Dent J 2012;57(2):178-83.