British Journal of Applied Science & Technology
18(4): 1-6, 2016; Article no.BJAST.26398
ISSN: 2231-0843, NLM ID: 101664541

SCIENCEDOMAIN ***international***
www.sciencedomain.org

Comparative Evaluation of Fluoride Release from Three Glass Ionomer Cements – An *in vitro* Study

Suvidh Virmani[1], Mithra N. Hegde[1], Shishir Shetty[1] and Vandana Sadananda[1*]

[1]Department of Conservative Dentistry and Endodontics, A. B. Shetty Memorial Institute of Dental Sciences, Nitte University, Deralakatte, Mangaluru, India.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJAST/2016/26398
Editor(s):
(1) A. A. Hanafi-Bojd, Department of Medical Entomology & Vector Control, School of Public Health, Tehran University of Medical Sciences, Iran.
Reviewers:
(1) Arthur Kemoli, University of Nairobi, Kenya.
(2) Rafael Menezes Silva, Bauru School of Dentistry, Bauru, São Paulo, Brazil.
(3) Yong-Keun Lee, ICPB and ETN Dental Clinic, Seoul, Korea.
(4) Hacer Deniz Arısu, Gazi University, Turkey.
Complete Peer review History: http://www.sciencedomain.org/review-history/17599

Original Research Article

Received 14th April 2016
Accepted 14th January 2017
Published 26th January 2017

ABSTRACT

Aim: The study aimed to measure the amount of fluoride released from fluoride containing materials. Zirconia reinforced glass ionomer cement (Zirconomer, SHOFU INC), high density glass ionomer cement (Ketac^{TM} Molar, 3M^{TM} ESPE^{TM}) and packable posterior glass ionomer restorative material (GC Fuji IX GP) were used in the study.
Methodology: Thirty samples of 2 mm length × 2 mm width × 2 mm height were prepared from each material using a custom made Teflon mould. The amount of fluoride released was measured after 7 hrs, 14 hrs, 24 hrs, 48 hrs, 5th day, 10th day, 15th day and 20th day of immersion in artificial saliva using Ion Specific Electrode (ELIT 9801). The results obtained were statistically analyzed using ANOVA and post hoc Tukey test.
Results: Ketac molar exhibited maximum release of fluoride followed by Zirconomer and Fuji IX. Significant statistical difference was observed in fluoride release of different materials after 14 hrs, 24 hrs, 5th, 10th and 20th day ($p<0.05$).
Conclusion: All materials used in the present study released fluoride, but a higher rate of fluoride release was observed in packable posterior glass ionomer material compared to zirconia reinforced glass ionomer material and high density glass ionomer material.

**Corresponding author: E-mail: vandanasadananda@gmail.com;*

Keywords: Zirconomer; fluoride; Ketac molar; Fuji IX; glass ionomer.

1. INTRODUCTION

Dental caries an infectious, multifactorial disease remains the most prevalent chronic disease. There is growing evidence supporting the in action ideas that dental caries can be controlled by altering the bacterial flora in the mouth, modifying the diet, increasing the resistance of the tooth to acid attack or reversing the demineralization process [1].

Knowledge of the aeitology of caries and its sequelae, advancements in research and availability of dental materials, growing evidence supporting less invasive management of dental caries is observed. In clinical practice, utilization of fluorides and sealants has been shown to be successful in reducing dental caries [2].

The beneficial role of fluoride for oral and dental health is well documented and undisputable. Among fluoride releasing materials, the glass ionomer materials are essential materials in clinical practice, frequently used for minimally invasive restorative procedures because of their versatile role of inhibition of early stages of demineralization, self-adhesion and good biocompatibility [3-6].

Dental materials containing fluoride exhibit marked differences in the release of fluoride and uptake characteristics and may serve the role of fluoride reservoir to increase the level of fluoride level in saliva, hard dental tissues or help in prevention or reduction of secondary caries [7].

Restorative material with inclusion of zirconia fillers has been introduced in the market. Conventional glass ionomer cements exhibit low wear resistance and marginal integrity, and is often cited as a reason to exclude them as an occlusal restorative material. Manufacturers claim reinforcement of structural integrity of the restoration due to superior mechanical properties such as high flexural modulus and compressive strength for the restoration of posterior load bearing areas with a combination of outstanding strength, durability and sustained fluoride protection for anti-cariogenic benefits in patients with high caries risk [6,8].

In clinical perspective, it is crucial that any modifications in the material to improve physical and/or mechanical properties must not compromise the fluoride releasing properties [9]. Amount of fluoride released from zirconia reinforced glass ionomer is not well documented in the literature, thus it is imperative to know the amount of fluoride released when compared to other glass ionomer materials already adopted in clinical practice as amount of fluoride release is of paramount importance to achieve the cariostatic and antibacterial effects. This study aimed at comparing and evaluating the amount of fluoride released from zirconia reinforced glass ionomer cement (Zirconomer, SHOFU INC, high density glass ionomer cement (Ketac^{TM} Molar, 3M^{TM} ESPE^{TM}) and packable posterior glass ionomer restorative material (GC Fuji IX GP).

2. MATERIALS AND METHODS

Three glass ionomer materials, Zirconia reinforced glass ionomer cement (Zirconomer, SHOFU INC), high density glass ionomer cement (Ketac^{TM} Molar, 3M^{TM} ESPE^{TM}) and packable posterior glass ionomer material (GC Fuji IX GP) were tested in this study.

The samples were prepared according to the manufacturer's instructions and packed into custom made Teflon moulds of 2 mm length × 2 mm width × 2 mm height. The specimens of each group (n=10) subsequent to coating with dental varnish were immersed in sterile containers containing 20 ml of artificial saliva (Sodium chloride 0.4 g/l, potassium chloride 0.4 g/l, calcium chloride-H_2O 0.795 g/l, sodium sulphur-H_2O 0.005 g/l, sodium dihydrogen phosphate-H_2O 0.69 g/l, distilled water 1000 ml) with a pH of 5.5 and stored at 37℃ in the incubator.

Fluoride ion concentration in the artificial saliva was determined after 7, 14, 24, 48 hrs and 5th, 10th, 15th and 20th day. The samples were removed, dried and placed in new sterile containers containing artificial saliva after each time interval. 1ml of TISAB II (Total ionic strength adjustment buffer NaOH 5.8 g, CDTA 0.4 g, NaCl 3 g, Acetic acid) was added to the artificial saliva to decomplex the fluoride and provide constant ionic strength. Fluoride release measurement was recorded using ion specific electrode (ELIT 9801) after thoroughly shaking the solution. The concentration of fluoride in the sample solutions was recorded in ppm [7,9].

The results obtained were statistically analyzed ANOVA and post hoc Tukey test.

3. RESULTS AND DISCUSSION

3.1 Results

All the materials evaluated in the study released fluoride during the entire time period. Maximum amount of fluoride release was related to Ketac molar followed by Zirconomer and then Fuji IX. The highest amount of fluoride release was seen after 7 hrs for Zirconomer, 24 hrs for Ketac molar and 48 hrs for Fuji IX followed by a decrease in the consequent days (Fig. 1). Statistical analysis of the data showed significant differences (p value < 0.05) in the mean amount of fluoride release between the groups at 14 hrs, 24 hrs, 5th, 10th and 20th day (Tables 1 and 2).

3.2 Discussion

Any modifications employed in the material to improve physical and/or mechanical properties must not compromise the fluoride releasing properties. Fluoride released from fluoride containing restorative materials effectively protect the tooth tissues from demineralization in the area adjacent to the restorative materials [10,11].

Initial release of fluoride reduces the number of viable bacteria and induces remineralization of enamel and dentin [12]. Fluoride release from the material brought about by diffusion is affected by the concentration of the particles and the material matrix. Diffusion of fluoride from the matrix exposed on the surface of the material is rapid. This phenomenon of "burst effect" is usually seen during the first two days [13,14,15,16]. A large concentration of the fluoride becomes part of the matrix during the acid dissolution of the powder particle surfaces. Fluoride release decreases rapidly, stabilizing after 2 to 3 weeks. Constant release of fluoride for long periods of time favours prevention of progression of lesions.

Table 1. One way ANOVA test to compare the three groups in each time period separately

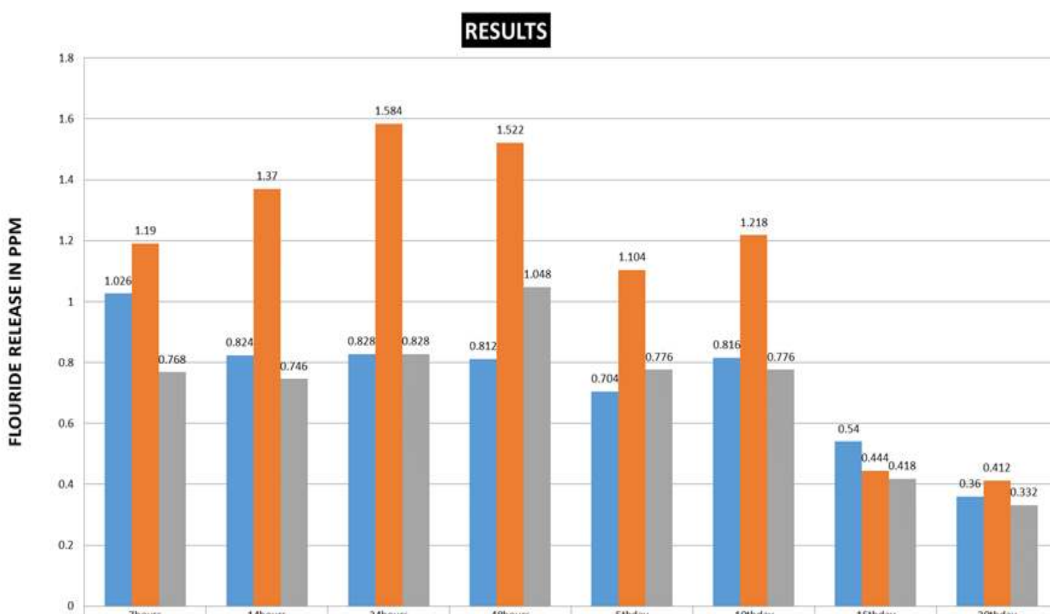
Time	Group	N	Mean	Standard deviation	Significance
7 hours	Group A (Zirconomer)	10	1.026	0.396	0.121
	Group B (Ketac Molar)	10	1.190	0.365	
	Group C (Fuji IX)	10	0.768	0.170	
14 hours	Group A (Zirconomer)	10	0.824	0.194	0.047*
	Group B (Ketac Molar)	10	1.370	0.409	
	Group C (Fuji IX)	10	0.746	0.132	
24 hours	Group A (Zirconomer)	10	0.828	0.203	0.028*
	Group B (Ketac Molar)	10	1.584	0.446	
	Group C (Fuji IX)	10	0.828	0.130	
48 hours	Group A (Zirconomer)	10	0.812	0.182	0.112
	Group B (Ketac Molar)	10	1.522	0.639	
	Group C (Fuji IX)	10	1.048	0.351	
5th day	Group A (Zirconomer)	10	0.704	0.047	0.035*
	Group B (Ketac Molar)	10	1.104	0.255	
	Group C (Fuji IX)	10	0.776	0.108	
10th day	Group A (Zirconomer)	10	0.816	0.097	0.031*
	Group B (Ketac Molar)	10	1.218	0.266	
	Group C (Fuji IX)	10	0.776	0.048	
15th day	Group A (Zirconomer)	10	0.540	0.152	0.326
	Group B (Ketac Molar)	10	0.444	0.684	
	Group C (Fuji IX)	10	0.418	0.033	
20th day	Group A (Zirconomer)	10	0.360	0.032	0.006*
	Group B (Ketac Molar)	10	0.412	0.019	
	Group C (Fuji IX)	10	0.332	0.036	

**p<0.05 statistically significant*

Table 2. Posthoc Tukey test

Time	Group (I)	Group (J)	Mean difference (I-J)	Standard deviation	Significance
10th day	Group A (Zirconomer)	Group B (Ketac Molar)	-0.402	0.105	0.006*
		Group C (Fuji IX)	0.040	0.105	0.923
	Group B (Ketac Molar)	Group C (Fuji IX)	0.442	0.105	0.003*
14 hours	Group A (Zirconomer)	Group B (Ketac Molar)	-0.546	0.172	0.020*
		Group C (Fuji IX)	0.078	0.172	0.894
	Group B (Ketac Molar)	Group C (Fuji IX)	0.624	0.172	0.009*
15th day	Group A (Zirconomer)	Group B (Ketac Molar)	0.096	0.256	0.926
		Group C (Fuji IX)	0.122	0.256	0.884
	Group B (Ketac Molar)	Group C (Fuji IX)	0.026	0.256	0.994
20th day	Group A (Zirconomer)	Group B (Ketac Molar)	-0.052	0.019	0.042*
		Group C (Fuji IX)	0.028	0.019	0.329
	Group B (Ketac Molar)	Group C (Fuji IX)	0.080	0.019	0.003*
24 hours	Group A (Zirconomer)	Group B (Ketac Molar)	-0.756	0.185	0.004*
		Group C (Fuji IX)	0.00E+00	0.185	1
	Group B (Ketac Molar)	Group C (Fuji IX)	0.756	0.185	0.004*
48 hours	Group A (Zirconomer)	Group B (Ketac Molar)	-0.710	0.274	0.057
		Group C (Fuji IX)	-0.236	0.274	0.674
	Group B (Ketac Molar)	Group C (Fuji IX)	0.474	0.274	0.235
5th day	Group A (Zirconomer)	Group B (Ketac Molar)	-0.400	0.103	0.006*
		Group C (Fuji IX)	-0.072	0.103	0.767
	Group B (Ketac Molar)	Group C (Fuji IX)	0.328	0.103	0.020*
7 hours	Group A (Zirconomer)	Group B (Ketac Molar)	-0.164	0.206	0.713
		Group C (Fuji IX)	0.258	0.206	0.448
	Group B (Ketac Molar)	Group C (Fuji IX)	0.422	0.206	0.144

**p<0.05 statistically significant*



	7hours	14hours	24hours	48hours	5thday	10thday	15thday	20thday
Group A (Zirconomer)	1.026	0.824	0.828	0.812	0.704	0.816	0.54	0.36
Group B(Ketac Molar)	1.19	1.37	1.584	1.522	1.104	1.218	0.444	0.412
Group C (Fuji IX)	0.768	0.746	0.828	1.048	0.776	0.776	0.418	0.332

Fig. 1. Fluoride release of the materials in ppm

In the present study maximum amount of fluoride release was observed by Ketac molar at 24 hrs, 1.584 ppm. Zirconomer exhibited maximum amount of release of fluoride at 7 hrs, 1.026 ppm followed Fuji IX at 48 hrs, 1.088 ppm. Fluoride release by Zirconomer was constant from 14 hrs up to 10 day with a decline thereafter. According to a study conducted by Xiaoming Xu, John O. Burgess they reported more release of fluoride from Fuji IX when compared to Ketac Molar over a period of 21 days while study conducted by S.A. Mazzaoui et al. reported that fluoride released is more from Ketac Molar when compared to Fuji IX over a period of 28 days [17,18].

Fluoride elution is affected by various factors such as composition, solubility, fluoride content of the material, porosity, nature of the dissolving medium, pH of oral cavity and temperature [18]. The pattern of rapid elution of fluoride by Zircomer may be attributed to the finely controlled micronization of the glass ionomer particles as claimed by the manufacturers. It is in conjunction with results reported by various studies that smaller glass particles provide a larger surface area, which increase the acid-base reactivity, and hence, have increased capacity to release fluoride from the powder more rapidly thereby increasing the fluoride release of the materials [14,19,20].

In this study artificial saliva was used to measure fluoride release to better simulate the oral environment and more clinically relevant than deionized water, buffers and organic acids. However as observed in a study conducted by El Mallakh and Sarkar, 1990 and Damen et al. 1996 the amount of fluoride released in artificial saliva is lower than in deionized water [21,22,23].

Slow and constant release of fluoride from restorative materials may have enormous clinical implications *in vivo*. Fluoride release from the materials is followed by a continuous uptake process involving increase in the fluoride concentration in the saliva and adjacent hard tissues, thereby decreasing demineralization of the hard tissues [7]. According to Cate et al. dentin demineralization was inhibited in clinically relevant percentage at fluoride levels above 1 ppm [24]. The effect of the pattern of release of fluoride needs to be further studied.

4. CONCLUSION

Within the limitation of the study it can be concluded that Ketac Molar released higher amount of flouride followed by Zirconomer and Fuji IX respectively. Highest amount of fluoride was released on 24th hours followed by 48th hour and least amount on the 20th day.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kumar JV, et al. Fluoride in dental public health programs. Dent Clin N Am. 2008;52: 387-401.
2. Schwendicke F, Domenjean S, Ricketts D, Peters M. Managing caries: The need to close the gap between the evidence base and current practice. Br. Dent. J. 2015; 219:433-438.
3. Ngo H, Opsahl S. Vital. Minimal intervention dentistry II: Part 7. Minimal intervention in cariology: The role of glass-ionomer cements in the preservation of tooth structures against caries. Br. Dent. J. 2014;216:516-565.
4. Zafar MS. Effects of surface pre-reacted glass particles on fluoride release of dental restorative materials. World Appl. Sci. J. 2013;28(4):457-462.
5. Nakajoa K, Imazatob S, Takahashib Y, Kibab W, Ebisub S, Takahashia N. Fluoride released from glass-ionomer cement is responsible to inhibit the acid production of caries related oral Streptococci. Dent Mater J. 2009;25:703-708.
6. Ten Cate JM, Van Duinen RNB. Hypermineralization of dentinal lesions adjacent to glass-ionomer cement restorations. J. Dent. Res. 1995;74:1266-1271.
7. Mousavinasab AM, Meyers I. Fluoride release by glass ionomer cements, compomer and giomer. Dent Res J (Isfahan). 2009;6(2):75-81.
8. Mount GJ. Clinical performance of glass-ionomers. Biomaterials. 1995;54(19):573-579.
9. Neelakantan P, John S, Anand S, Sureshbabu N, Subbarao C. Fluoride release from a new glass-ionomer. Operative Dentistry. 2011;36(1):80-85.
10. Tarn LE, Chan GP, Yim D. *In vitro* caries inhibition effects by conventional and resinmodified glass-ionomer restorations. Oper Dent. 1997;22(1):4-14.

11. Glasspoole EA, Erickson RL, Davidson CL. Demineralization of enamel in relation to the fluoride release of materials. Am J Dent. 2001;14(1):8-12.
12. Tay FR, Pashley EL, Huang C, Hashimoto M, Sano H, Smales RJ, et al. The glass-ionomer phase in resin-based restorative materials. J Dent Res. 2001;80(9):1808–12.
13. Delbem AC, Pedrini D, Franca JG, Machado TM. Fluoride release/recharge from restorative materials—effect of fluoride gels and time. Oper Dent. 2005;30(6):690-695.
14. Weigand A, Buchalla W, Attin T. Review on fluoridereleasing restorative materials—Fluoride release and uptake characteristics, antibacterial activity and influence on caries formation. Dent Mater J. 2007;23(3):343-362.
15. Yap AU, Tham SY, Zhu LY, Lee HK. Short-term fluoride release from various aesthetic restorative materials. Oper Dent. 2002;27(3):259-265.
16. Levallois B, Fovet Y, Lapeyre L, Gal JY. *In vitro* fluoride release from restorative materials in water versus artificial saliva medium (SAGF). Dent Mater J. 1998; 14(6):441-447.
17. Xiaoming X, Burgess JO. Compresive strength, fluoride release and recharge of fluoride-releasing materials. Biomaterials. 2003;24:2451-2461.
18. Mazzoui SA, Burrow MF, Tyas MJ, Dashper SG, Eakins D, Reynolds EC. Incorporaion of casein phosphopeptide-amorphous calcium phosphate into a glass ionomer cement. J Dent Res. 2003;82:914-918.
19. Weidlich P, Miranda LA, Maltz M, Samuel SMW, Fluoride release and uptake from glass ionomer cements and composite resions. Braz Dent J. 2000;11(2):89-96.
20. Karantakis P, Antonaides MH, Pahini ST, Papadogiannis Y. Fluoride release from three glass ionomers, a compomer and a composite resin in water, artificial saliva and lactic acid. Oper Dent J. 2000;25(1): 20-25.
21. El Mallakh BH, Sarkar NK. Fluoride release from glass ionomer cements in deionized water and artificial saliva. Dent Mater J. 1990;6:118-122.
22. Damen JJM, Buijs MJ, Ten Cate JM. Uptake and release of fluoride by saliva-coated glass ionomer cement. Caries Res. 1996;30:454-457.
23. Vermeersch G, Leloup G, Vreven J. Fluoride release from glass-ionomer cements, compomers and resin composites. J Oral Rehabil. 2001;28(1):26-32.
24. Ten Cate JM, Damen JJ, Buijs MJ. Inhibition of dentin demineralization by fluoride *in vitro*. Caries Res. 1998;32(2): 141–7.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/17599