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Original Article

Dentistry Section

Invitro Evaluation of Fluoride Release from Hydroxyapatite Reinforced Glass Ionomer with or without Protective Coating

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ABSTRACT

Introduction: Glass Ionomer Cement (GIC) is well known for its fluoride releasing property but has its own drawbacks of poor mechanical properties, sensitivity to initial desiccation and moisture contamination. To overcome these, search led to the reinforcement of hydroxyapatite and application of surface coating agent but their effect on fluoride release is still not clear.

Aim: To evaluate and compare the release of fluoride from Hydroxyapatite Reinforced Glass Ionomer (HA-GIC) with and without protective coating.

Materials and Methods: Specimens were prepared as follows- Eight percent by weight conventional glass ionomer was replaced by hydroxyapatite powder (HA) and an indigenous product was prepared (HA-GIC). This powder was mixed with liquid of conventional GIC and allowed to set, then G coat plus coating agent was applied in surface coated group and light cured. Fluoride release of the sample was measured every 24 hrs for seven days and weekly from 7th to 21st day using combination ion selective electrode.

Results: Mean values clearly reveal a significant decrease in the fluoride release from day 1 to day 21 for both the groups. Results of repeated measure ANOVA revealed statistically significant difference between two groups ($p < 0.001$).

Conclusion: Coating the hydroxyapatite reinforced glass ionomer will allow for slow and steady release of fluoride for a long period of time into oral environment.

Keywords: Conventional glass ionomer, Indigenous product, Restorative material

INTRODUCTION

The high morbidity potential of dental caries has brought the disease into the main focus of dental professionals [1]. The role of fluoride in the prevention of dental caries is very well known and applied in dentistry. With the advent of fluoride releasing restorative material, Glass Ionomer Cement (GIC) came into existence. The favorable properties of glass ionomer make it a useful material in paediatric dentistry, still its use in clinics is limited due to it's drawbacks of poor mechanical properties, sensitivity to initial desiccation and dehydration [2].

To overcome drawbacks of GIC further research in this field led to the incorporation of hydroxyapatite whiskers as strengthening material for GIC [3]. The composition and crystal structure of hydroxyapatite is same as apatite in human dental structures and skeletal system and it exhibits excellent biological behavior. The interaction between glass ionomer and hydroxyapatite is through carboxylate [4]. Studies have proved that reinforcing hydroxyapatite into GIC improves its mechanical properties without impeding its sustained fluoride release [5,6]. Application of protective coating during initial setting of GIC prevents moisture contamination and dehydration [7]. The twenty first century is the era of nanotechnology.

Nanofillers improve the wear resistance of coating agent thus providing more protective coating over glass ionomer cement [8]. Fluoride release from hydroxyapatite reinforced glass ionomer and nanofilled surface coated conventional glass ionomer has been reported in our previous studies [8,9] but the effect of nanofilled coating agent on fluoride release from HA- GIC, an indigenously made product has not yet been reported in the literature. Thus, this study is designed in the continuation of our previously published studies [8,9] to evaluate the effect of nanofilled surface coating agent on fluoride release from HA-GIC.

MATERIALS AND METHODS

The present study was conducted in the Department of Paediatric and Preventive Dentistry, JSS Dental College in year 2012. For the preparation of HA-GIC, Eight weight percent of the conventional glass ionomer was replaced by hydroxyapatite powder (HA) and hand mixed before addition of polyacid liquid. Total 80 specimens (40 each group) of HA-GIC were prepared for the study. Specimens were fabricated by placing restorative material (HA-GIC) into the teflon mold (5 mm diameter × 2 mm height) supported by glass slide in the mounting jig [10]. Then they were further sub divided into two groups 1- Non- Coated HA-GIC (control group), 2- Surface Coated HA-GIC.

GROUP 1 - For non coated HA-GIC (control group) prepared specimens remained uncoated. **GROUP 2 -** For surface coated group G coat plus coating agent was applied on specimens and light cured.

Prepared specimens were suspended individually in 25ml of distilled water and stored at 37°C in an incubator. Fluoride release of sample was measured every 24 hours for seven days and weekly from 7th to 21st day using combination Ion Selective Electrode (ISE) from HACH Company with Sension4 pH/ISE/MV Laboratory Meter. This equipment is more powerful, versatile, accurate and cost-effective as compare to other methods. It can measure fluoride in variety of solutions and it is sensitive to wide range of concentrations (10-7- saturated solution) [8].

STATISTICAL ANALYSIS

Collected data was tabulated on Microsoft excel and data was analyzed using SPSS software version 17. The statistical analysis applied were descriptive statistics, Repeated Measure ANOVA, Independent Sample t-test, Paired Sample t-test and Scheffe Post-Hoc test ($\alpha = 0.05$).

RESULTS

Mean (± SD) fluoride release (ppm) from both groups (surface coated and non- coated) is given in [Table/Fig-1,2]. Mean values clearly reveal a significant decrease in the fluoride release from day 1 to day 21 for both the groups. Results of repeated measures ANOVA revealed statistically significant difference between two groups (p <0.001) [Table/Fig-3].

Independent t-test revealed significant differences between two groups on all the days with t-values which are highly significant (p<0.001) [Table/Fig-4]. The pattern of fluoride release was also found to be different for both the groups throughout the experimental period [Table/Fig-1&2]. Comparison was made between mean values of surface coated HA-GIC and surface coated conventional GIC (results of our previous study [8]). In our previous study by applying Independent t-test which revealed non-significant differences between these two materials on all the days with t-values which are non significant (p>0.05) except on 14th day where significant difference is present between two material with t-value which is significant (p <0.01) [Table/Fig-5].

DISCUSSION

Fluoride plays a major role in prevention of recurrent caries. Various fluoride releasing restorative materials have been described in the literature. Among them most widely used is GIC. This present study was designed to evaluate the effect of protective coating on fluoride release from hydroxyapatite reinforced glass ionomer, an indigenously made product (HA-GIC). In the present study this indigenous material (HA-GIC) was made by replacing eight weight percent of the glass ionomer powder by hydroxyapatite powder (particle size 5-20 microns) [9] as this proportion of hydroxyapatite led to the highest increase in flexural strength [5] and it did not impede fluoride release from this indigenous product [6,8].

Fluoride release was significantly more in non -coated group as compared to surface-coated group and non-coated group showed initial burst of fluoride release for two days then declined sharply on 3rd day and gradually diminished to a nearly constant level. Other studies by Roeland JG et al., H K Yip et al., have demonstrated similar fluoride release pattern from different glass ionomer products [11,12]. The reason for initial burst of fluoride release from non-coated HA-GIC might be due to high solubility of immature hydroxyapatite-reinforced glass ionomer without protective coating. Fluoride release from surface coated HA-GIC was less as compared to non coated group which is consistent with our previous study on conventional glass ionomer [8] [Table/Fig-5] and also with study by C McKnight-Hanes et al., G W Castro et al., SA Mazzaoui et al., [13-15] [Table/Fig-6]. Pattern was gradual for first seven days and then decreased to constant level for next 15 days. It is hypothesized that components (metharylate) of coating agent might chemically interact with hydroxyapatite, thus influencing the fluoride release from this indigenously made product (HA-GIC). Nano-filled protective coating on HA-GIC an indigenously made product, reduced the initial burst effect of fluoride release letting on dilatory and steadfast release of fluoride for prolonged period into the oral cavity, thus helping in re-mineralization by providing more available fluoride to the cavity walls.

Treatment Group Surface	N	Day 1	Day 2	Day 3	Day 4	Day 5	Day6	Day 7
Coated	40	3.2660±0.3305	2.2905±0.1754	1.7519±0.1306	1.0951±0.0716	0.6367±0.1295	0.2828±0.0445	0.0813±0.0114
Non-coated	40	7.3840±0.4120	6.5807±0.1754	3.5061±0.3229	2.5028±0.2516	2.1126±0.0698	1.8314±0.0937	1.0862±.0953

[Table/Fig-1]: Mean (± SD) fluoride release (ppm) from hydroxyapatite reinforced glass ionomer from 1 to 7 day.

Treatment Group	n	Day 1	Day 7	Day 14	Day 21
Surface Coated	40	3.2660± 0.3305	0.0813±0.0114	0.0078±0.0007	0.0046±0.0012
Non-coated	40	7.3840± 0.4120	1.0862±0.1198	0.5815±0.1000	0.0055±0.0009

[Table/Fig-2]: Mean (± SD) fluoride release (ppm) from hydroxyaptite reinforced glass ionomer at 1, 7, 14 and 21 days.

Source of Variation	Sum of squares	Mean squares	F-value	Sig
Duration	382.943	127.648	3672.664	0.000***
Duration*group	50.908	16.969	488.237	0.000***
Error (group)	1.877	0.035		
Group	40.577	40.577	853.982	0.000***
Error	0.855	0.048		

[Table/Fig-3]: Results of repeated measure ANOVA for mean fluoride release (ppm) from surface coated and non coated groups of hydroxyapatite incorporated glass ionomer at 1,7,14 and 21days.
***p< 0.001-very highly significant, **p<0.01- highly significant *p< 0.05- significant

Days	Groups	Mean±SD	Mean difference	t-value	df	Sig
Day 1	Surface coated	3.2660±0.3305	4.118	24.651	39	0.000***
	Non-coated	7.3840±0.4120				
Day 7	Surface coated	0.0813±0.0114	1.0049	26.386	39	0.000***
	Non-coated	1.0862±0.1198				
Day 14	Surface coated	0.0078±0.0007	0.5737	18.138	39	0.000***
	Non-coated	0.5815±0.1000				
Day 21	Surface coated	0.0046±0.0012	0.0009	1.774	39	0.000***
	Non-coated	0.0055±0.0009				

[Table/Fig-4]: Comparison between surface coated and non-coated groups of hydroxyapatite reinforced glass ionomer at 1,7,14 and 21 days.
***p< 0.001-very highly significant, **p<0.01- highly significant *p< 0.05- significant

Days	Groups	Mean±SD	Mean difference	Sig
Day 1	HA-GIC	3.2660±0.3305	0.0556	0.686
	GIC	3.2104±0.2728		
Day 7	HA-GIC	0.0813±0.0114	0.0718	0.290
	GIC	0.1531±0.2077		
Day 14	HA-GIC	0.0078±0.0007	0.0017	0.011**
	GIC	0.0095±0.0017		
Day 21	HA-GIC	0.0046±0.0012	0.0004	0.475
	GIC	0.0050±0.0012		

[Table/Fig-5]: Comparison of mean values of fluoride release between surface coated HA-GIC & surface coated conventional glass ionomer [8].
***p< 0.001-Very highly Significant, **p<0.01- Highly Significant *p< 0.05- Significant p value >0 .05-non significant

Sl. no	Author name	Result
1	Mcknight -Hanes et al.,[13]	Varnishing the discs caused 61-76% reduction in fluoride release depending upon product.
2	G.W Castro et al., [14]	Order of cumulative fluoride release-Uncoated (control) group 100% >visiobond 57%>scotchbond II 39%>Variglass37%> varnish 26%.
3	S.A Mazzouni et al., [15]	Coating the discs caused 43-74% reduction in fluoride release depending upon product. Total amount of fluoride released from Uncoated group (2.3-85.4 ppm) > coated group (<.2ppm-24.1ppm).
4	Tiwari et al., [8]	Coating the discs caused approx. 60% reduction in fluoride release.
5	Present study	Coating of the disc caused average of 65% reduction in fluoride release.

[Table/Fig-6]: Tabular comparison between similar previous studies.

LIMITATION

Invitro design is the major limitation of this study, thus further clinical investigation regarding the longevity of HA-GIC and nanofilled protective coating in the oral cavity should be carried out to authorize its use in clinical dentistry.

CONCLUSION

A perfect restorative material is clinician's hour of need. So turning to account HA-GIC with protective coating would be a commendable choice for clinicians providing improved mechanical and fluoride releasing properties without desiccation and moisture contamination during its initial set. Also, it is aesthetic, easy to handle and bonds chemically to the tooth structure. Thus being pragmatic for primary and permanent posterior teeth, high salivary flow patients, medically and developmentally compromised patients and in places where use of composite is critical.

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