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An In-vitro Comparative evaluation of fluoride release from Cention N, GIC, Composite and metal modified GIC at different pH levels.

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Abstract

Aim: To evaluate and compare the fluoride release of new material with conventional fluoride releasing posterior restorative materials.

Methodology: Total of 96 specimens, 24 of each restorative material (8 for each medium) was prepared from 4 restorative material (Cention N, Fuji IX GIC, Tetric N ceram, Miracle Mix) using customized Teflon mould. The Samples of each group was then randomly divided into 3 subgroups with 8 samples in each subgroups based on the study medium (medium A, B, C) in which it was suspended. Medium A, B & C consists of deionized water, artificial saliva, Ph cycling model respectively. Each sample were then placed in individual polypropylene vials containing 9 ml of their respective study medium and fluoride estimation was done using ORION fluoride ion specific electrode at the end of day 1, 15, 30, 90 and 180.

Results: Miracle Mix have shown to have high fluoride releasing property in deionized water, artificial saliva and pH cycling model compared to Fuji IX and tetric N ceram at all time intervals. Cention N released significantly more amount of fluoride release in pH cycling model as compared to others.

Conclusion: Cention N shows less fluoride release as compared to Fuji IX GIC and Miracle Mix in deionized water and artificial saliva. In pH cycling model which is frequently encountered in oral cavity the maximum amount of fluoride is released by Cention N compared to all 3 materials.

Keywords: Fluoride release, Cention N, Fuji IX GIX, Tetric N ceram, Miracle Mix.

Introduction

Dental caries is one of the most prevalent chronic diseases worldwide and is the most common cause of tooth loss and pain in the oral cavity.[1,2] Prevention of secondary caries is an important goal in the treatment of dental caries. For prevention of caries, role of fluoride has been well-documented in literatures.[3] Fluoride when present in low and sustained quantities in the oral fluids during an acidic condition is able to inhibit demineralization and protect teeth from the deteriorating effect of acid. Hence, fluoride releasing restorative materials which are able to provide sustained release of fluoride are used to inhibit caries initiation in adjacent teeth also prevents secondary caries formation.[4]

There are several direct filling materials are used in modern dental practice among which GICs are most frequently used.[5] Glass ionomer cements (GIC) are water-based, self-adhesive restorative materials, it is considered as a fluoride ions reservoir which maintains a scontinuos release of fluoride ions into the surrounding tooth structure, thus enhancing the resistance to secondary caries.[5] Miracle Mix (GC, Corp.,Japan) is a metal modified GIC it have shown increase fluoride release [6,7] Disadvantages of Miracle mix is that it produces tooth discolouration. Tetric N-Ceram®(TNC) is a light-cured, hybrid composite for direct restorations. Tetric N ceram is a BisGMA based composite resin containing fillers such as Ytterbium fluoride (YbF_3) which shows cumulative release of fluoride from the material.[8]

Cention N is a newer restorative material that belongs to a class of alkasites, that can give tooth-colored esthetics with high flexural strength.[9]

It can increase the release of hydroxide ions which regulates the pH during acidic conditions, which prevents demineralization. More importantly, it can release a sustained amount of fluoride ions along with calcium ions which helps in remineralization of dental enamel and prevent dental caries as claimed by the manufacturers.[9,10]

Caries prevention property of these restorative materials depends on amount and duration of fluoride release, specially at acidic pH (below the critical level of pH 5.5).[11]

Several studies have been reported on pattern of fluoride release under neutral pH or in inert solutions like deionized or double distilled water. Very few studies are present on caries inducing acidic pH which actually occurs in the mouth. Also very limited researches are present on fluoride releasing pattern of Cention N. Hence, in this study, we compared the fluoride releasing properties of an alkasite (Cention N), a conventional glass ionomer cement (Fuji IX GIC), composite resin (Tetric N Ceram) and a metal modified GIC (Miracle Mix), in different storage medium at different time intervals.

Materials And Methods

Study design: This was an in vitro study carried out in the Department of Conservative Dentistry and Endodontics, Karad, Maharashtra from the year 2017 to 2020. Ethical approval was obtained from the Institutional Ethical Committee before initiating the study (Ref No. KIMSDU/IEC/02/2018).

Preparation of the specimens: The restorative materials used in this study includes Cention N (Ivoclar Vivadent), Fuji IX GIC (GC Corp., Japan), Tetric N Ceram (Ivoclar Vivadent) and Miracle Mix GIC (GC Corp., Japan).

24 samples were made from each restorative material (Group I – Cention N , Group II – Fugi IX GIC, Group III – Tetric N ceram , Group IV – Miracle mix) resulting in total of 96 samples.

The restorative materials were manipulated as recommended by manufacturer for each material and was then placed in Telfon moulds (8 mm diameter and 2 mm depth) and pressed between mould and glass slab to obtain uniform standardized disc.

The materials of group I, II and IV was allowed to set inside the mould for 10 minutes through chemical curing. Whereas materials of group III were light cured for recommended time periods of 20 seconds. Samples of each group were further divided into 3 subgroups based on the medium used viz. Subgroup A (1A, 2A, 3A, 4A) suspended in Medium A, Subgroup B (1B, 2B, 3B, 4B) suspended in Medium B and Subgroup C (1C, 2C, 3C, 4C) suspended in Medium C (Table 1).

Groups	Sub group	Number of specimens
Group I (24)	1A= Deionized water	8
	1B= Artificial saliva	8
	1C= pH cycling model	8
Group II (24)	2A= Deionized water	8
	2B= Artificial saliva	8

	2C= pH cycling model	8
Group III (24)	3A= Deionized water	8
	3B= Artificial saliva	8
	3C= pH cycling model	8
Group IV (24)	4A= Deionized water	8
	4B= Artificial saliva	8
	C= pH cycling model	8

Storage medium preparation :

Medium A: Deionized water. It was procured from milli-Q, Millipore system in the laboratory.

Medium B: Artificial saliva was prepared by mixing Ca 1.5 mM ($CaCl_2$ 0.1665 g/l), PO_4 0.9 mM (NaH_2PO4 0.133 g/l), KCl 150 mM (KCl 11.184 g/l), Tris buffer 20 mM (2.4228 g/l), and NaN_3 0.02%, pH was adjusted to 6.8 by adding dilute HCl.

pH cycling model: Consists of **Medium C 1 and Medium C 2. Medium C1**(Demineralizing solution was prepared by using Ca, PO_4 , Acetate buffer, and NaN_3. Its pH was made to 5.2 by adding dilute HCl and dilute NaOH. Solution of **Medium C2** was artificial saliva at pH 6.8.

Samples of Subgroup A and B were placed in a polypropylene vials containing 9 ml of their respective medium and incubated at a constant temperature of 37±0.5°C for 24 hours. After 24 hours, samples were removed from the vials and rinsed with 1 ml of flowing distilled water into the previous 9 ml of respective medium to make it 10 ml. Subsequent transfers were carried out similarly for all samples at the end of 1st, 15th, 30th, 90th and 180th day and each reading were recorded. Samples of subgroup C were placed in demineralizing solution for 6 hours and then transferred to the remineralizing solution for 18 hours for the pH cycling process. The samples were transferred to a fresh medium for the next reading at the end of 1st day and subsequently for 15th, 30th, 90th and 180th day.

Estimation of fluoride release : Fluoride ions released in each respective medium was estimated using a ORION digital ion analyser (EA 940 Orion Analyzer, Orion Research, Inc.) equipped with combination ORION fluoride ion specific electrode (9609BN Orion Research, Inc.). (Fig.1). before fluoride estimation, 1st the fluoride specific electrode was calibrated with standard fluoride solution of 1 and 10 ppm (parts per million). The estimation of fluoride release in each samples solution was done by taking 10 ml of sample aliquot to which 1 ml of total ionic strength adjustment buffer (TISAB-III) solution was added as buffer and stirred for 60 seconds and then the tip of the previously calibrated fluoride ion specific electrode was completely dipped in the solution. (Fig:1) and the reading displayed (PPM) on the digital screen was recorded.

Figure 1: Fluoride ion specific electrode

Statistical analysis

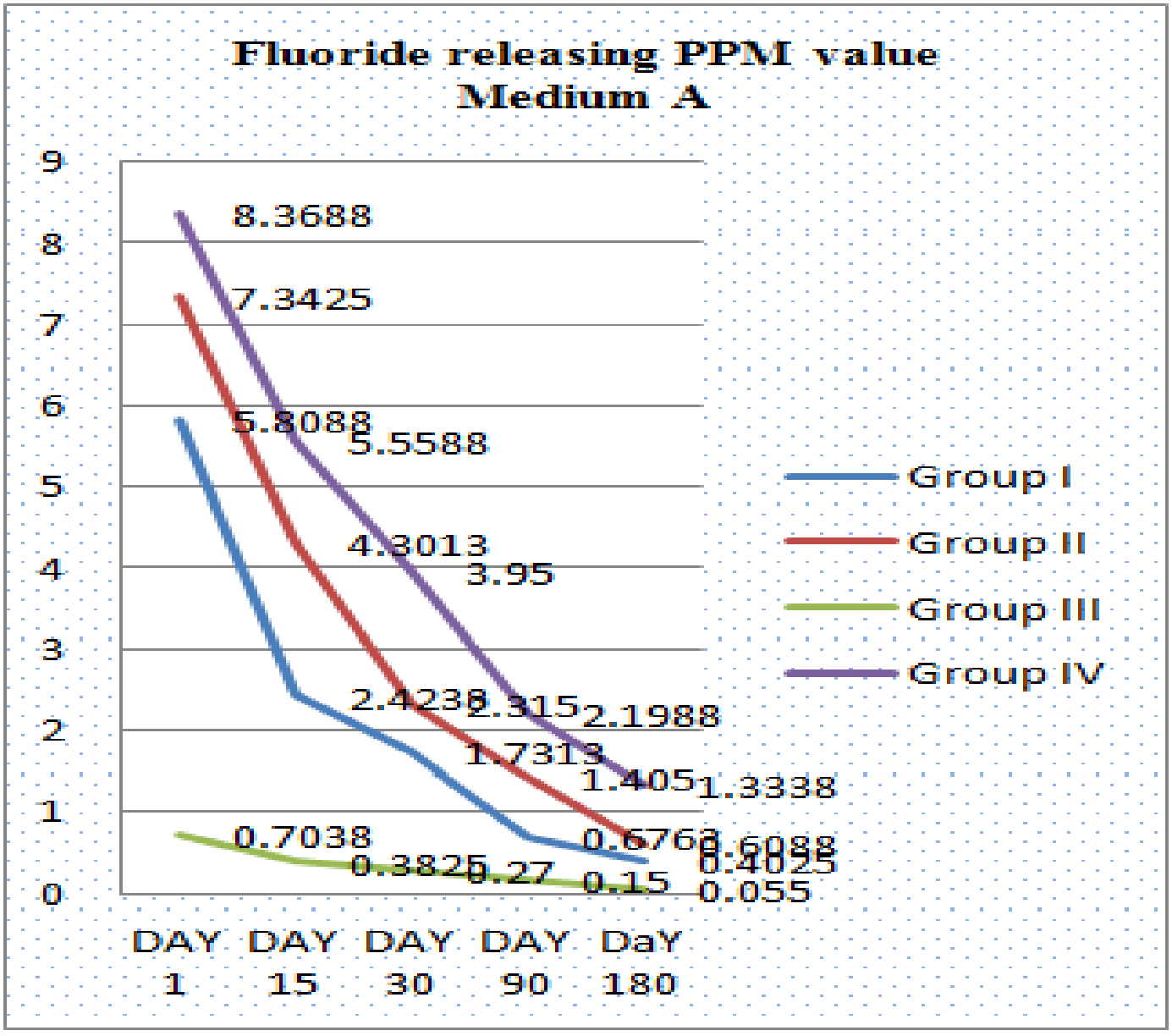
The data obtained from 96 samples were entered in Microsoft Excel Spreadsheet and analyzed by the software IBM® SPSS Statistics for Windows, Version 20.0.

Descriptive statistics which were expressed as mean ± standard deviation (SD) for value. Tukey's Post Hoc test was used to test the pair wise of comparison of the four groups. For all analyses, a *P* value of <0.05 was considered as statistically significant.

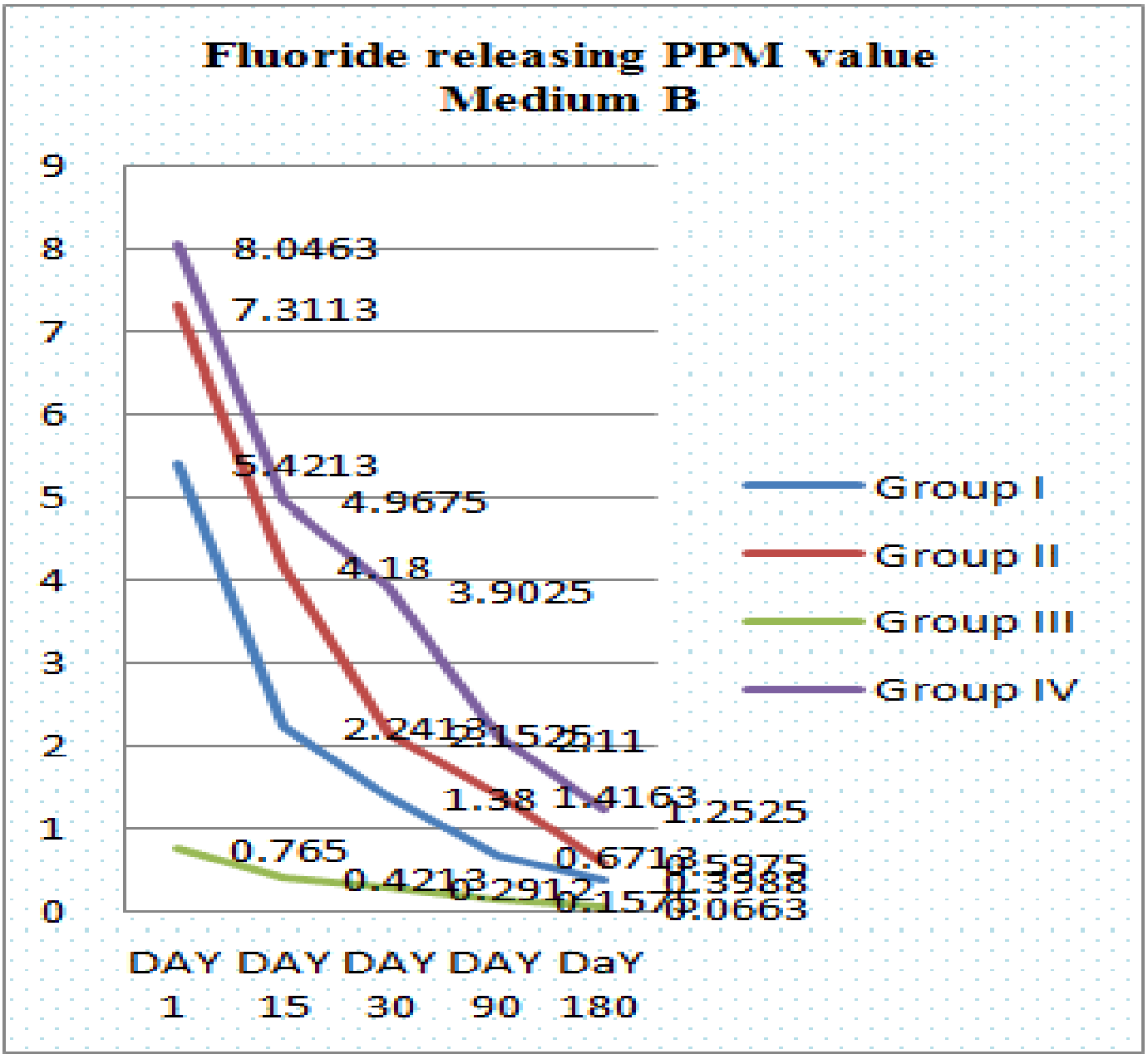
Results

The mean fluoride release values of all four materials in different media are given in Table 2. The pattern of fluoride release in all the groups were similar but there was a great difference in the amount of fluoride ion released. Fluoride release in Medium C was consistently higher compared to Medium A and B. Intergroup comparison showed that in medium A and B, Group IV released highest amount of fluoride followed by > group II > Group I > and group III at all time period (Table 2, Graph 1 & 2). However in Medium C fluoride release was seen maximum in Group I followed by Group IV > Group II > Group III (Table 2, Graph 3). The mean fluoride release is significantly different between Medium A and Medium C (*P*<0.0001) and Medium B and Medium C (*P*<0.0002). In pairwise comparison of all the four groups, statistically significant difference was observed in all the three storage media at different time interval (P<0.01). (Table 3)

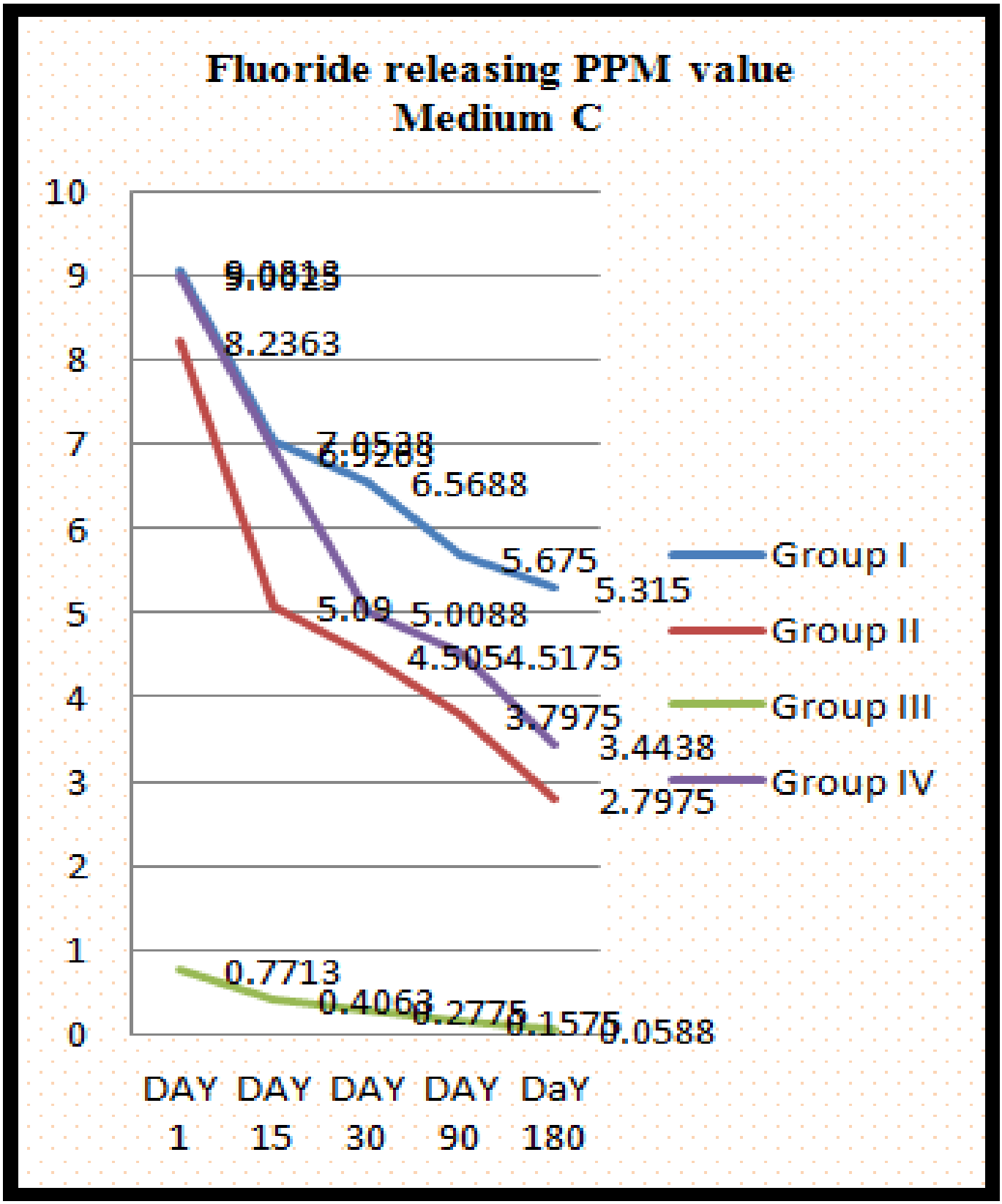
	Day 1	Day 15	Day 30	Day 90	Day 180
Group I					
Medium A	5.80	2.42	1.731	0.676	0.40
Medium B	5.51	2.24	1.424	0.671	0.39
Medium C	9.08	7.05	6.56	5.678	5.31
Group II					
Medium A	7.34	4.30	2.31	1.40	0.608
Medium B	7.31	4.18	2.15	1.16	O.59
Medium C	8.23	5.09	4.50	3.80	2.79
Group III					
Medium A	0.70	0.38	0.27	0.15	0.055
Medium B	O.65	0.36	0.25	0.13	0.055
Medium C	0.77	0.40	0.27	0.15	0.058
Group IV					
Medium A	8.36	5.55	3.95	2.19	1.33
Medium B	8.04	4.99	3.90	2.11	1.25
Medium C	9.00	6.92	5.00	4.51	3.43



Graph 1: Comparison of fluoride release in PPM among GroupI, II, III and IV at various interval of time in Medium A.



Graph 2: Comparison of fluoride release in PPM among Group I, II, III and IV at various interval of time in Medium B.



Graph 3: Comparison of fluoride release in PPM among Group I Group II Group III and Group IV at various interval of time in Medium C.

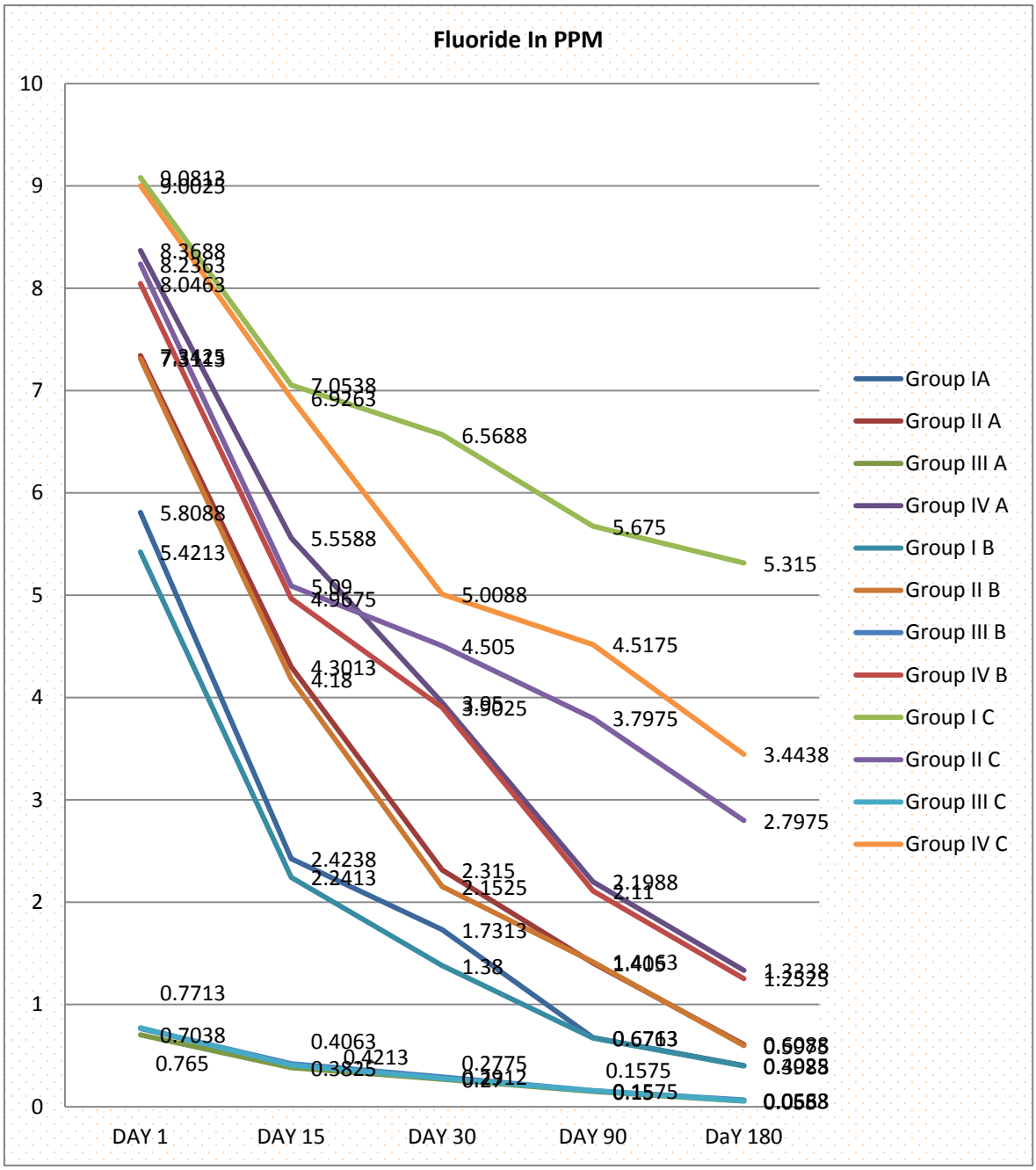


Table 3: Pairwise comparison of different media and groups with respect to fluoride release

Variables	Mean Difference	SD	P Value
Pair of Media			
Medium A-Medium C	-1.935	0.136	<0.0001*
Medium B-Medium C	-2.047	0.136	<0.0002*
Pair of Groups			
Group I-Group III	3.327	0.157	<0.0001*
Group I-Group IV	-1.04	0.15	<0.0002*

Group II-Group III	3.4	0.157	<0.0003*
Group II-Group IV	-0.968	0.157	<0.0004*
Group III-Group IV	-4.37	0.15	<0.0005*

SD: Standard deviation; *: Tukey's Post Hoc test

Discussion

Prevention and mitigation of dental caries has been challenging to dentists worldwide. The presence of fluoride ions in low concentration during an acidic condition are able to inhibit demineralization of teeth and prevent further progression of caries.[12] various factors affecting fluoride release are temperature, type of solvent, area of material exposed and powder liquid ratio of the restorative materials.[4]

In this study all the samples were prepared by single operator to avoid and rule out any discrepancies. Deionized water was chosen as it provides the baseline of fluoride release.[4,13,14] Artificial saliva was used to simulate natural oral cavity.[15] The 3rd medium selected was pH cycling model to simulate a caries inducing situation encountered in the oral cavity.

Results of Intragroup comparisons shows that the maximum amount of fluoride release is seen at 1st day which decreases gradually from 1st to 180 days.

There was an initial surge in the release of fluoride ions observed in the first day. This finding agrees with Xu et al, where glass ionomer cement and resin modified glass ionomer cement have a high release of fluoride which decreases gradually over a long period of time.[16] The burst effect is due to the initial burst of fluoride ion from the surface of the material which is then followed by bulk diffusion where small amounts of fluoride release is continued for a couple of years.[17,18]

Results (Table 2, Graph 4) shows consistently higher level of fluoride fluoride release in pH cycling model than in other 2 medium. Lower value in artificial saliva may be due to the ionic effect of cations and anions on the solubility of the material.[4,13,14] The significant difference reveals that disintegration of dental materials is also dependent on the type of solvent.

In the present study all of the tested restorative materials (Cention N, Fuji IX GIC, Tetric N Ceram and Miracle Mix GIC) showed the release of detectable levels of fluoride throughout the six-month test period. Tetric N Ceram was shown to release the least amount of fluoride ions when compared to the other materials in all the 3 mediums. The above observation is in accordance with Dasgupta et al, where they found that Tetric N Ceram had the least amount of fluoride release.[19] Tetric N Ceram comprises of Ytterbium trifluoride (YbF3) filler which is the main fluoride source, where the release of fluoride is not a result of the oral environmental setting but is attributed to the passive leaching of fluoride ions from the filler particles by exchange reaction due to the absorption of solvents by the material.[16]

In all the three storage media (Deionised water, Artificial saliva and pH cycling model), Fuji IX GIC released higher amount of fluoride ions than Tetric N Ceram but lower amount compared to Miracle Mix. Fuji IX is a glass ionomer cement which has high fluoride releasing property and the capacity to buffer storage solutions.[16,20] Miracle Mix significantly released higher amount of fluoride ions than Cention N and all of the other restorative materials. The release of fluoride ions by Miracle Mix is considered to be significantly greater due to its inhomogeneous mixture of glass powder and amalgam alloy.[7]

In neutral pH (Medium A and Medium B), Cention N had shown to release lesser amount of fluoride ions compared to Fuji IX GIC and Miracle Mix. This could be because

Fuji IX GIC has a comparatively higher filler content (99.9%) compared to 78.4% in Cention N, out of which, only 24.6% of the material is responsible for fluoride ion release in neutral pH.[15, 21, 22] In addition to this, fillers in Cention-N are surface modified, thus becoming resistant to degradation and this may lead to the release of a lesser amount of fluoride ions.[23] Whereas, Cention N has shown to release significantly higher amount of fluoride ions in the pH cycling model relative to the other tested materials. The presence of lower pH environment deteriorates the surface resistant layer of cention N more aggressively, thus exposing the matrix for the increased release of fluoride ions.[9]

Cention N was observed to be the most effective in the pH cycling model at all time intervals, which is advantageous during an acid challenge compared to other restorative materials. Thus, it can be used as an alternative to the other restorative materials used in this study.

Since this is an in vitro test, the clinical success of any substance cannot be determined by in vitro analysis alone. Regulated clinical trials are required in order to draw a definite conclusion on the fluoride release of various restorative materials. Since, Cention N is a relatively new restorative material, more researches are necessary to come to a definite conclusion.

Conclusion

Cention N shown to have better fluoride releasing property in acidic conditions. Thus it can be used as alternative to Glass ionomer cement , miracle mix and tetric N ceram bulk fill for posterior restorations, as it is a cost-effective, fluoride releasing material with both strength and good esthetics.

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