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Original Research

Comparison of Two Resins with Fluoride Release and Uptake Property of Giomer and Polyacid Modified Composite-An In Vitro Assessment

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ABSTRACT

Aim: The purpose of this study was to investigate the release of fluoride ions by different dental restorative materials and to compare their fluoride uptake after application of topical fluoride agents: APF gel and NaF gel. **Material & Methods:** The samples(5 mm in diameter x 2 mm in height)total 20 specimens of two fluoride releasing dental restorative materials were fabricated according to the manufacturer's instructions and were randomly divided into two groups. These specimens were immersed in 10 ml of artificial saliva and the amount of fluoride released was measured on 1st (24 hrs), 3rd, 7th & 14th day. On 14th day all the specimens of each group were divided into two sub- groups of 5 specimens each and placed in 2ml of APF gel & 2ml of NaF gel for 4 minutes for recharge of these materials and again the release of fluoride from recharged specimens was estimated. **Result:** The fluoride released from the various materials was significantly different. The higher release was shown by thepolyacid modified composite (compomer) then Giomer.

Key words: Fluoride; giomer; polyacid modified composite.

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INTRODUCTION

Fluoride is well accepted as an anticariogenic agent and it seems that it may be able to reduce recurrent caries[1]. Many mechanisms are involved in the anticariogenic effects of fluoride, including the formation of fluoroapatite, with solubility lower than the original carbonated apatite, thus the enamel resistance to subsequent acid attack is increased, remineralization is enhanced and carbohydrate metabolism in dental plaque is inhibited.

Due to these beneficial effects delivery of fluoride is accomplished by several means, most commonly by fluoridation of public water supplies, fluoridated dentifrices, mouth rinses and consequently, development of restorative materials that facilitate constant delivery of flouride directly to the susceptible tooth surfaces. It is reported by Kidd (1992)[2] and Arends (1995)[3] that approximately half of all restorative dentistry work is in the form of replacement of restorations, and about 60% of replacements are attributed to secondary caries. This lead to

introduction of new restorative materials in the last decades with fluoride releasing property aimed at inhibiting recurrent decay. Henceforth extensive amount of work has been performed to evaluate fluoride release from restorative materials and recharge ability of these materials.[4].One such group of material is the "Glass Ionomer" introduced by Wilson and Kent (1972)[5] which has important properties, such as chemical bonding to tooth structure and bio-compatibility and antimicrobial activity with shortcomings like sensitive to moisture contamination and esthetics.

In the 1990s resin-modified glass ionomers was developedby Mathis and Ferracane (1989).[6] They hadbeneficial properties of the glass ionomer's, such as long-term fluoride release and the ability to be recharged with topically applied fluoride with better esthetic and handing characteristics. But resin-modified glass ionomers later found to get discoloured over the time as compared to composites as observed by McCabe (1998).[7] So to overcome the short coming of resin-modified glass ionomers,in early 1990's polyacid modified resin composite "Compomers" were developed which combine the best properties of glass ionomers and composite resins. Although they have better esthetics, easier to place and polish, than GICs, they release less fluoride and could not be recharged. In the continuing quest for improved glass ionomer-like restoratives, manufacturers have developed and introduced a new class of materials called "Giomers." They are a hybrid of "glass ionomer" and "composite". They have properties of both glass ionomers (fluoride release, fluoride recharge) and resin composites (excellent esthetics, easy polishability, biocompatibility). Giomers are distinguished by the fact that, while they are resin-based, they contain pre-reacted glass-ionomer (PRG) particles. The particles are made of fluorosilicate glass that has been reacted with polyacrylic acid prior to being incorporated into the resin. Giomers have inherent property of fluoride release over a period of time with recharging property as noticed by Itotaa(2004),[8] Dhull(2009)[9] which is the most important property in terms of caries prevention. The purpose of this study was therefore, to examine the fluoride releasing ability of two different resin based materials containing fluoridated glass filler and comparing the recharging ability of these materials after exposure to topical fluoride.

MATERIALS & METHODS

The materials used for this study were one polyacid modified composite resin (Compomer) and oneGiomer (Table 1). Total number of 20 specimenswere made and randomly divided into two groupconsisting of 10 specimen each using Teflon mould of size 5 mm in diameter x 2 mm in height. The materials Giomer (Beautifil II) and Compomer (Dyract Extra) were placed into the mould and light cured using Dentsply light curing unit. The prepared discswere subjected to thermal cycling (500 cycles) at5^0C-37^0C - 55^0C with dwell time of 15 secondsin controlled water bath. The artificial saliva was prepared according to Macknight Hane and Whitford (1992) [10] formula and the specimenswere immersed in artificial saliva. The artificialsaliva was changed on daily basis to avoidfluoride saturation of the solution. The release offluoride in artificial saliva was estimated beforeapplication of topical fluoride on 1st, 3rd, 7th and14 day. On 14th day each group was furtherdivided into two subgroups of 5 specimens eachand two topical fluoride ie APF gel and NaF gel were applied for 4 min and washed with distilledwater to remove the residual material. Againestimation of fluoride was done for next 14 daysat predetermined days. To determine the amountof fluoride release, 1 ml of TISAB III was mixedin 10 ml of sample solution. Fluoride ion analysiswas performed by ion selective electrode methodusing expandable ion analyzer (Thermo Orionmodel 96-09) and combination fluoride electrode.In each session, the electrode was calibrated withserially standard fluoride solutions containing 0.1,1, 10, 100 ppm fluoride, diluted with 10% v/vTISAB III. The fluoride concentration of the solutions were separately measured for each sample on day 1,3,7 and 14th day.

Table 1 (Materials used in the study)

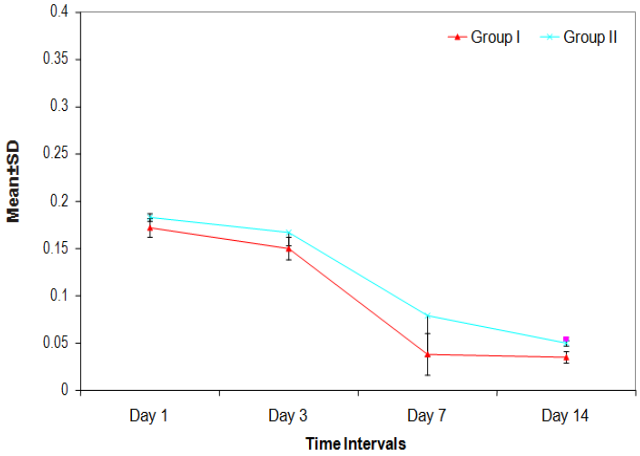
Product	Manufacturer	Group No
Giomer -Beautifil II	SHOFU INC. Kyoto, Japan	I
Compomer-Dyract Extra	DENTSPLY, Germany	II
APF gel 1.23%	Pascal Company, WA, USA	
NaF gel 2.71%	Septodent Company , France	

RESULTS

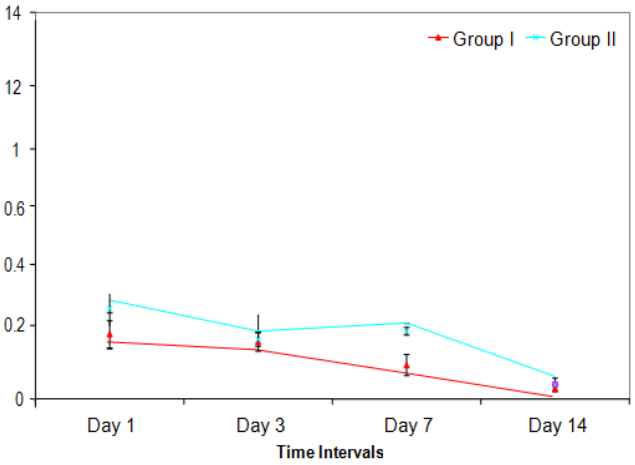
Mean Fluoride Release before recharge at day1st, 3rd, 7th and 14th for both groups, indicated that at all the time intervals group II showed maximum fluoride release with mean value 0.183±0.004 ppm on day 1 whereas group I showed less

fluoride release with mean value 0.172±0.010 ppm. It was observed that with passage of time there was decrease in amount of fluoride release in both the two groups. Maximum fluoride release on day 14 was observed to be 0.050±0.003 ppm for group II whereas lessfluoride release was observed for group I 0.035±0.006ppm(Graph1). A statistically significantdifference was seen among the two groups for fluoride releaseat all time intervals ($p<0.001$). Group II> Group I. On rechargewith APF, group II had the maximum meanfluoride (0.311+0.041ppm) release while groupI had the minimum fluoride (0.137+0.016 ppm) release 24 hours after recharging. With passage oftime, a continuous decrease in fluoride releasewas observed in all groups (Graph2). While on recharge with NaF mean

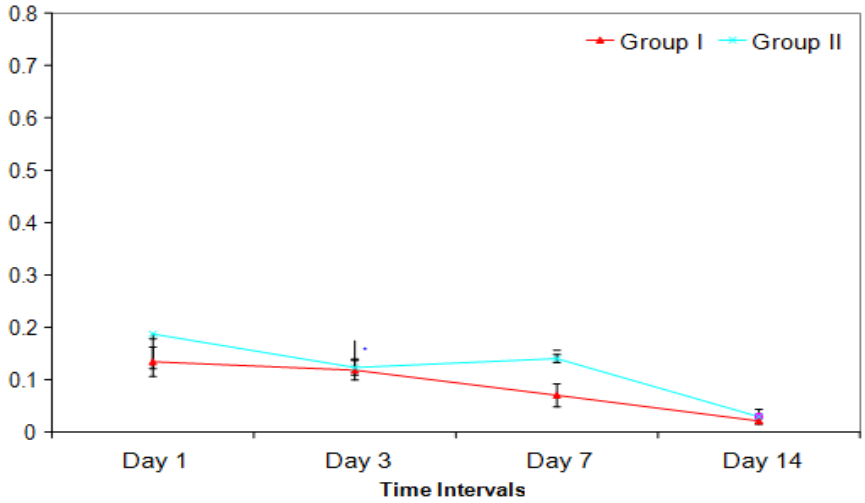
fluoride release in differentgroups at all the time intervals, group II had themaximum value (0.187+0.066ppm , 0.123+0.014ppm, 0.140+0.008ppm, 0.029+0.014 ppmrespectively) whereas group I had minimumvalue (0.134+0.028 ppm, 0.118+0.019 ppm,0.070+0.022 ppm, 0.021+0.004 ppm respectively)on all days(Graph3). Withpassage of time, a decrease in mean fluoridelevels was observed in both thegroups. Theintra group comparisons of fluoride release beforeand after recharge with topical fluoride APF/NaF with respect to time, in group I & II mean fluoriderelease on day 1 before recharging in 10 sampleswas of lower order as compared to afterrecharging with APF and NaF. Maximum fluoriderelease was found when samples were rechargedwith APF than with NaF. The intra groupcomparisons of fluoride release in group I, mean fluoride release on day 1,3,14 was higherin before recharge samples than samples recharged with NaF and APF. While on day 7recharged samples with APF and NaF, both had higher release of fluoride than before recharged samples but this difference was found to be statistically significant only for APF samples. Incase of group II on day 1 the samples recharged with APF & NaF showed significantly higher fluoride release than that of before rechargesamples. While on day 3 the samples rechargedwith APF showed a higher fluoride release than samples recharged with NaF and the before recharge samples. On day 7 the mean fluoriderelease was found to be significantly higher forrecharged samples APF and NaF both as compared to before recharge. While on day 14,both the recharged samples with APF and NaF showed lesser fluoride release (mean 0.021±0.003ppm & 0.029±0.014 ppm respectively) thanbefore recharge samples (baseline) value(0.050±0.003 ppm), but the results were notfound to be significant statistically.



Graph 1: Mean fluoride release in different groups at different time intervals before recharge (in ppm)



Graph 2: Mean fluoride release in different groups at different time intervals after recharging with 1.23% APF (in ppm)



Graph 3: Mean fluoride release in different groups at different time intervals after recharging with 2.71% NaF (ppm)

DISCUSSION

The aim of this study was therefore, to examine the fluoride releasing ability of two resin based materials containing fluoridated glassfiller and comparing the recharging ability ofthese materials after exposure to topical fluoride.In the present study artificial saliva was used as aspecimen storage solution so as to simulate anenvironment similar to oral cavity for fluoriderelease. The artificial saliva was changed everyday in the present study to prevent saturation ofthe solution as reported by Yap *et al*.,[11] whonoticed that frequency of change of the storagemedia is a critical factor and storage for morethan 24 hours may lead to saturation. Thermocycling was done, which simulates thechanges in temperature in oral environment.Hence in the present study, samples were thermocycled between 5°C, 37°C, 55°C, so as tomaintain a difference of 49°C, whichapproximates the maximum temperature rangemeasured in vivo, as demonstrated bySimmons.[12] Fluoride ion selective electrodemethod was used in the present study to measurethe amount of fluoride released by the materials,as it is a direct calibration method and it measurestotal fluoride concentration containing both freefluoride ions and fluoride complexes. Both Compomer and Giomer did not show initial fluoride 'burst' effect rather there was steady release of flouridewhich were in accordance with study by Attar *et al*.,[13] Yap *et al*.,[11]Dhull*et al*.[9]

In the present study, Giomer, released less fluoride than the Compomer which were contradictory to study done by Itotaa*et al*.,[8]; Dhull*et al*.,[9] but it were in accordance with study done by Mousavinasab *et al*.,[14] who found that there wassignificant differences in the amount of fluoride release between Compomer and Giomer. Thisexplains that fluoride released by resin basedmaterials, is not only affected by the formation ofcomplex fluoride compounds and theirinteraction, but also by the type and amount ofresin used for the photochemical polymerizationreaction. Beautifil (Giomer) which contains surface pre reacted glass ionomer (S-PRG) as a fluoride componentshowed little amountof fluoride release in this study. The fluoride glass within Beautifil has little or no glass ionomer matrix phase, because of the lack of any significant acidbase reaction. As PRG has been reacted with fluoro aluminosilicate glass and acid, water absorption is not critical in the acid base reaction asseen in this study which were similar to theresults of other studies done by Yap *et al*,[11]Itotaa*et al*.[8] Compomers resemble traditional composite resins in that their setting reaction by polymerization. Dyract extra a third generation compomer used in present study showed low diffusion fluoride release. Dyract includes fluoride containing acid degradable glass strontium fluoride and ion leachable glass fillers that are smaller in size than in composites. Its initial setting is performed by light-activated polymerization which is followed by an acid–base reaction that arises from sorption of water into the cement from the surroundings, leading to controlled diffusion of fluoride from the material. The similar findings were reported by Wiegand *et al*.[4] All materials in the present study showed a steady decrease in release of fluoride with time. Giomer, have PRG fillers that are already been pre-reacted with polyacrylic acid, so water sorption is not critical in the acid-base reaction process. Fluoride release is via an exchange mechanism in direction of the lowest fluoride concentration. The amount of fluoride release decreases with time due to diminishing gradient, as fluoride is leached out from the material as noticed by Yap *et al*.[11] This explains the steady decline of fluoride release from Beautifil in the present study over the entire period of the present experiment. For Compomer, the present study was also in agreement with several earlier studies done by Vermeersch *et al*.,[15]Eliades *et al*.,[16] that the fluoride release content reduces with time. It may be owing to the formation of a silica gel layer covering the glass particles, thus subsequently declining the fluoride release. Fluoride containing dental materials usually show clear differences in the fluoride release and uptake characteristics which may act as fluoride reservoir to increase fluoride level in saliva, plaque and hard dental tissues, or may help to prevent or reduce secondary caries. After recharging the specimen with APF gel or NaF gel, the fluoride release from both materials increased substantially after 24 hours (first day). The release did not declined quickly to the baseline level till 72 hours i.e., 3 days since first recharge and there after continuous decrease was seen. These result were in accordance with several previous studies Suljak*et al*.,[17]Rothwell*et al*.,[18] Preston *et al*.,[19] where the 'brief burst' effect was reported due to recharged superficial part of the specimens. However, the material with higher initial fluoride release has also shown a higher ability of fluoride recharge in the present study similar to the study done by Xu *et al*.[20] In present study, exposure to APF gel or NaF gel had equal effects on the amount of fluoride release from both materials except that samples recharged with APF released more fluoride which were in accordance with the studies conducted by Diaz-Arnold *et al*.,[21] Gao*et al*.[22] This was probably because of low pH of APF gel containing phosphoric acid and hydrofluoric acid which erodes the surfaces of many restorative materials and contribute to the high release of fluoride and other ions. The permeability of the materials was also likely to be a major factor in the fluoride recharge mechanism. The more permeable material has more ability to absorband then release fluoride. Moreover, the porosity of the materials may have an influence on the amount of fluoride release before and after recharge. Higher porosity will allow deeper diffusion of the recharge agent into the material and results in a higher content of fluoride storage and release. On the other hand, the material with high porosity has disadvantages on the mechanical properties. An example for this is the material with less resin content, such as resin-modified GICs. Due to their higher porosity, they exhibit higher fluoride recharge capabilities. Nevertheless, their

strength is lower than that of compomer and resin composite. In addition, the viscosity of fluoride recharge agents may be a factor for fluoride release. The gel viscosity may be difficult to remove from pores and cracks of the specimens by gentle washing as observed by Gao*et al*.[22] Although Giomers are claimed to be fluoride rechargeable as the pre-reacted surface zone of the glass particles seems to act as a reservoir for fluoride ions the pattern of fluoride re-release did not differ from other materials' pattern. The present study supports the rechargeable behavior of materials also observed by Cildir and Sandalli,[23]Debem*et al*.,[24] in their studies. However, fluoride release after exposure to topical fluoride gels occurred in high amount within 2 days after recharge. In the clinical situation, this would mean that fluoride would be constantly released as long as the subject continues rinsing, brushing, or chewing fluoridated products. The cumulative fluoride release levels of materials after topical fluoride application were generally lower than those released from the freshly prepared specimens after 28th day. The values of liberated fluoride vary substantially from one study to another. This may be attributed to a lack of uniformity in specimen shape and size, process of the experiment, nature of the aqueous environment used, and even the equipment employed to express fluoride release. Hence, although there are lots of studies available in this direction, it is difficult to compare the results from all them.

CONCLUSION

However the present study was in-vitro study where freshly prepared specimens had shown significant variations in fluoride release and recharge potential. This study might not be able to arrive at any conclusive results until compared to in-vivo study conducted with long term follow up. The further investigations are required to clarify the fluoride recharge mechanism as it is not certain whether the fluoride uptake or recharge properties play any important role in prevention of secondary caries around the restoration.

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