Original Article

The Effect of Cigarette Smoking on Solubility and Disintegration of Resin Modified Glass Ionomer Cement – An In Vitro Study

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Abstract

Introduction: Glass ionomer cement (GIC) is a dental restorative material that is prone to solubility and degradation. GIC could degrade in presence of water and desiccation due to environmental factors during setting process and eventually might lead to the failure of the restoration. Cigarette smoking brings a complex chemical mixture to oral cavity that can inhibit polymerization and promote the solubility of this cement. Therefore, the aim of this study was to evaluate the effect of cigarette smoking on solubility and disintegration of resin-modified glass ionomer cement (RMGIC). **Methods:** RMGIC used for preparation of control group (n=54) with same number of samples in test group (n=54). The test groups were exposed to cigarette smoking. Samples divided in groups of 6 to immerse in three different mediums (water, normal saline and qahwa, the Arabic tea) for the immersion periods of 1h, 24h and 7days. Differences in weight of each sample were recorded before and after immersion. One Way Anova followed by Tukey- Kramer multiple comparison test was used to analyze data. **Results:** Test group exhibited significant dissolution irrespective to the type of medium or duration of immersion. Therefore, exposure to direct or indirect cigarette smoking within the first hour of the setting time of RMGIC cause dissolution of it. In addition, consumption of qahwa, within one hour of cement placement causes initial dissolution in both control and test groups. **Conclusion:** Cigarette smoke exposure and consumption of qahwa drink within the initial hour of cement placement is not recommended**.**

Keywords: Cigarette smoke, Glass Ionomer Cement, solubility

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Introduction

Glass Ionomer cement (GIC) has various dental applications such as a cement, pulp protection and restorative material. The success of restorations depends mainly on characteristics of materials (1).Despite multiple advantages of GIC it is sensitive to moisture during the setting time that could potentially cause failure(2). Cigarette contains more than 4000 different chemical compounds. It has a complex mixture of various chemical compounds including chromium, arsenic, tar, benzene, polonium, formaldehyde, cadmium and other substances. These chemical compounds interfere with polymerization and increase solubility of the cement(3-7).In resin modified glass ionomer cement (RMGIC) polyacrylic acid has been replaced by polymerizable methacrylate monomer. This would lead to overcome sensitivity to moisture and solubility disadvantages of conventional GIC (2).However, exposure to chemical residues interfere polymerization and integration of resin cement (1, 2). Researchers report that cigarette smoking will affect color stability and adhesion of composite restorations (5, 6).Tar, arsenic and other such toxic fumes diminish color of fillings and surface finish which lead to weak binding (5). Thus, it is necessary to understand the effect of cigarette smoking

on solubility of dental cements. More than one billion individuals are smokers in world as per World Health Organization (WHO) report (3). Hence, the impact of cigarette smoking in dental restorative therapy could be an important concern. Glass ionomer cements (GIC) are one of the major dental materials. Disintegration of these materials can cause failure in restoration procedure (1,2). Although many studies have investigated effect of cigarette smoking on health hazards and dental treatment procedures, up to our knowledge, no study reported evaluating the consequence of smoking on properties of RMGIC. Therefore the present study aimed to assess the effect of cigarette smoking on solubility and disintegration of RMGIC by setting the null hypothesis H0 with no change in the properties of GIC after cigarette smoking.

Materials and Methods

For this in vitro study, RMGIC material was used. A hollow metallic cylindrical mold with 10mm diameter and 2mm thickness was used to prepare RMGIC samples. Control samples (n=54) fabricated as per the manufacturer guidelines and left to set in the mold without cigarette smoke exposure. For solubility test, each sample was weighed first (W1) and divided into three different control groups of Ca, Cb and Cc based on their immersion time (1hour, 24hours and 7days). Subgroups selected as 1, 2 and 3 based on medium of immersion such as water, normal saline and qahwa respectively. Samples were weighed again after immersion (W2). The difference in weight before and after immersion calculated as ΔW to evaluate the solubility of control samples in various liquid mediums at different time periods.

Cigarette smoking exposure test

A glass chamber prepared for cigarette smoke exposure. The test samples (n=54) were exposed to cigarette smoke once within the initial phase of setting. The test groups selected as Ta, Tb and Tc based on the immersion time (1hour, 24hours and 7days). Subgroups prepared as 1, 2 and 3 based on medium for storage such as water, normal saline and qahwa respectively. Samples after immersion weighed as W2. The difference in the weight before and after immersion calculated as ΔW to evaluate the solubility of the test samples in various liquid mediums at different time intervals.

Statistical analysis

Using a comparison of means formula, the sample size calculated as 6. The level of significance (Zα) and statistical power (Zβ) considered as 95 % and 80% respectively. From the pilot study conducted, the difference among groups and standard deviation estimated as 10 and 0.09 respectively. Data collected was analyzed using Graphpad instat software. Results subjected to One Way Analysis of Variance followed by Tukey Kramer multiple comparison test to understand the feasibility of results obtained.

Results

Table. I represents the dissolution rate of control samples in various immersion mediums and different time periods. A small amount of solubility exhibited irrespective of the medium and time of immersion. The solubility observed in water is comparatively lower with normal saline and Arabic drink qahwa ($P<0.001$). The time of immersion is directly related to the solubility of samples in all selected immersion medium ($P< 0.001$).

Table. II represents the solubility rate of the test samples in various immersion mediums and different time periods. A large amount of solubility was seen in all the test samples. Dissolution observed was lower for water compared to normal saline and qahwa ($P< 0.001$). Between 1hour to 7 days groups, a significant increase insolubility noted among samples soaked in water and normal saline ($P<0.001$). However, the initial solubility was higher in qahwa.

Figure 3.1 represents the comparison of solubility observed for control and test samples in water. There is a significant increase in the solubility rate for all test conditions ($P< 0.001$). Similar results observed for normal saline and qahwa as in figure 3.2 and figure 3.3. However, initial dissolution was higher in qahwa. Figure 3.4 represents the comparison among samples evaluated for all test criteria. Irrespective of the medium used, the test samples exhibited significant higher solubility rate ($P< 0.001$).

Table I. Change in weight of control samples after different immersion time

Trial	(Ca1)	(C_{a2})	(C_{a3})	(C_{b1})	(C_{b2})	(C_{b3})	(C_{c1})	(C_{c2})	(C_{c3})
1	0.0033	0.0055	0.0076	0.0046	0.0057	0.0076	0.004	0.0056	0.0076
2	0.0032	0.0054	0.0073	0.0039	0.0055	0.0075	0.0054	0.0052	0.007
3	0.0031	0.0052	0.008	0.0038	0.0056	0.0074	0.0036	0.0066	0.0076
4	0.003	0.0061	0.0073	0.0045	0.0053	0.0067	0.0044	0.0051	0.0069
5	0.0029	0.0054	0.0077	0.0043	0.0058	0.0077	0.004	0.0052	0.0084
6	0.0033	0.0053	0.0071	0.0037	0.0052	0.0079	0.0034	0.0058	0.0073
Mean ± SD	0.0031± 0.0002	0.0055+ 0.0003	0.0075+0 .0004	0.0041 ± 0.0004	0.0055 ± 0.0002	0.0075± 0.0004	0.0041+ 0.0007	0.0056 ± 0.0006	0.0075± 0.0005

In this C_{a1} represents control sample immersed in water for 1hour, C_{a2}= control samples immersed in water for 24 hours and C_{a3}= control sample immersed in water for 7 days. C_{b1}= control sample immersed in normal saline for 1 hour, C_{b2}= control sample in normal saline for 24 hours and C_{b3}= control sample in normal saline for 7 days. C_{c1}= control sample in qahwa for 1 hour, C_{C2} control sample in qahwa for 24 hours and C_{c3}= control sample in qahwa for 7 days

Table II. Change in weight of Test samples after different immersion time

Trial	(T_{a1})	(T_{a2})	(T_{a3})	(T_{b1})	(T_{b2})	(T_{b3})	(T_{c1})	(T_{c2})	(T_{c3})
1	0.0086	0.0078	0.0097	0.0092	0.0099	0.0094	0.0089	0.0099	0.0099
2	0.0085	0.0102	0.0096	0.0086	0.0098	0.0088	0.009	0.0088	0.0088
3	0.0086	0.008	0.0088	0.009	0.0094	0.0095	0.01	0.0093	0.0093
4	0.0085	0.0089	0.009	0.0099	0.0106	0.0089	0.0141	0.0099	0.0098
5	0.0089	0.0086	0.0093	0.0099	0.0092	0.0097	0.0103	0.0108	0.0097
6	0.0091	0.0104	0.0096	0.0096	0.0094	0.0102	0.0127	0.0095	0.0091
Mean ± SD	0.0087 ± 0.000245	0.0089± 0.0011	0.0093± 0.0004	0.0094± 0.0005	0.0097± 0.0005	0.0094± 0.0005	0.0108± 0.0021	0.0097± 0.0007	0.0094± 0.0004

In this T_{a1} represents test sample immersed in water for 1hour, T_{a2}= test samples immersed in water for 24 hours and T_{a3}= test sample immersed in water for 7 days. T_{b1}= test sample immersed in normal saline for 1 hour, T_{b2}= test sample in normal saline for 24 hours and T_{b3}= test sample in normal saline for 7 days. T_{c1}= test sample in qahwa for 1 hour, $T_{C2=}$ test sample in qahwafor 24 hours and T_{c3}= test sample in qahwa for 7 days

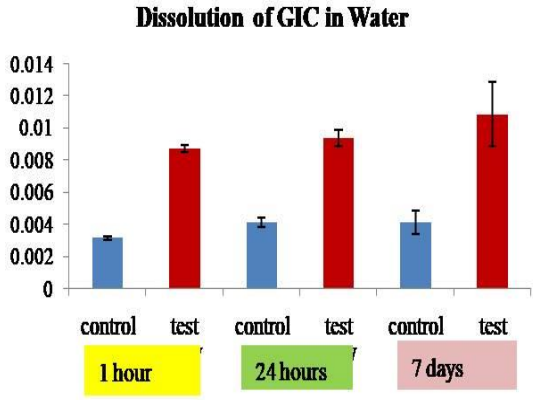

Figure 3.1: Dissolution of GIC (control and test groups) in water at various time intervals

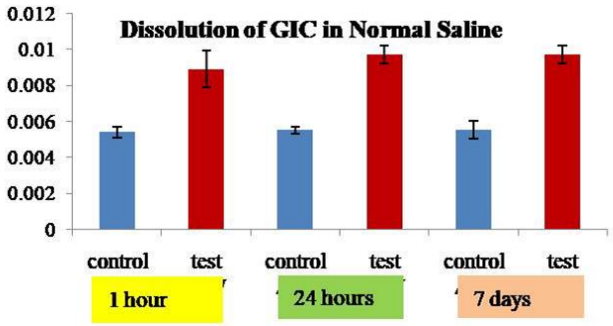

Figure 3.2: Dissolution of GIC (control and test groups) in normal saline at various time intervals

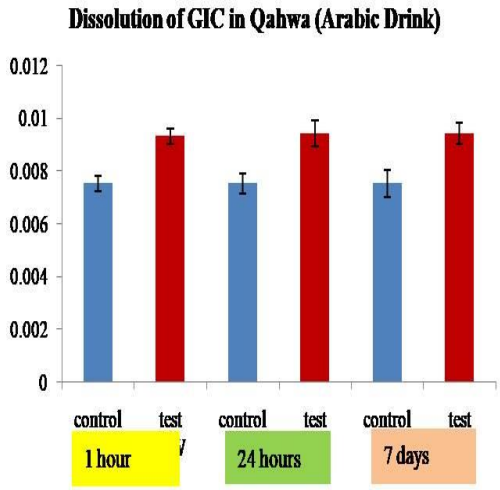

Figure 3.3: Dissolution of GIC (control and test groups) in qahwa, the Arabic drink at various time intervals

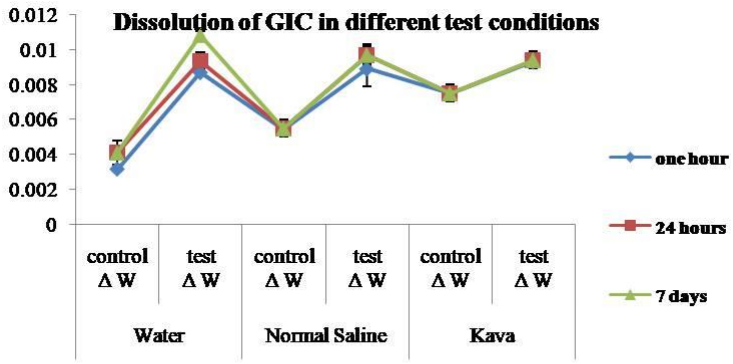

Figure 3.4: comparison of dissolution rate at various time intervals in different immersion medium

Discussion

Results of the present study revealed that cigarette smoking cause dissolution of the RMGIC regardless of the period and medium of immersion. Accordingly, the null hypothesis was rejected. Evaluation of dissolution and disintegration of restorative material is crucial as it affects the overall success of any restoration. A small amount of dissolution noted in all the samples irrespective of groups studied. Dissolution of cements occurs usually in the first 7 days of setting (8).Dissolution of glass ionomer cements believed to happen because of two main reasons. First, presence of sodium ions that lead to water-soluble salt formation and secondly the aluminium ions that react slowly with matrix-forming anions and tend to leach in water. Once these ions are bonded to matrix, it is resistant to dissolution even in acidic environments (9).Therefore, the dissolution behaviour within initial seven days is of prime concern for restorative materials. A steady fluoride release is beneficial for anti-cariogenic properties. However, the release of other essential ingredients may affect the structure and inherent properties of cement setting (10).The present study results observed a higher rate of solubility for control samples immersed in normal saline and qahwa compared to water. Studies report that both alkaline and acidic mediums can increase the dissolution rate of the polymeric materials compared to water (11-13). Significantly higher solubility was observed for test samples compared to all control samples ($P<0.001$). Due to cigarette smoking, temperature and humidity of the surrounding environment change and it might have altered interaction between elements in polymerization of dental materials. Change in the temperature and humidity during the setting of restorative materials can have a negative effect on their properties. A weak bond might have created due to the surrounding environment and a weight reduction observed in the test samples regardless of the medium and immersion time duration. In addition to this, rise in temperature may cause softening of the resin cement, which attributes to the additional dissolution with cigarette smoking-exposed samples (3). Moreover, the cigarette smoke formed by combustion and pyrolysis and exists in two phases, the vapour phase and particulate phase. In vapour phase, smoke consists of many different gases like oxygen, nitrogen, carbon monoxide, carbon dioxide, methane, hydrogen cyanide, acetaldehyde, acetone and nitric acid. In particulate phase, nicotine, water and tobacco-based nitrosamines are present. These products interact with the bonding mechanism of the polymeric chain and cause deleterious effect in binding properties. The components in particulate phase cause degradation of dental resins by plasticization and release of residual monomer that accelerates the weight loss during immersion (6). Discoloration of test samples was also noticed and this is along with other researches reporting that color of the polymeric and composite materials changes after cigarette smoking exposure (14-17). In other studies, a rough polymethyl methacrylate denture base obtained after exposure to cigarette smoke due to the increased temperature and the chemicals evolved during burning. Similarly, a rough surface might have created in present test samples that led to adhesion of chemical substances on sample surfaces causing discoloration. Increase in roughness of surface can cause penetration of liquid medium in which the samples are stored in; this might be another reason for increased solubility rate for smoke-exposed polymerized restorative dental cements (15, 16). Polymerized materials are soluble in aromatic hydrocarbons. Mathias et a. (14, 16). reported cigarette smoke tar contains aromatic hydrocarbons that increase dissolution of the polymerized materials. Tar depositions on the surface may penetrate the surface cracks and promote hydrolytic degradation of resin materials

(17).Nicotine in the cigarette smoke can alter the pH of the saliva in cigarette smokers. The same effect expected in the pH of the immersion medium, this may also have attributed to the increased solubility of the test samples as the pH changes in the storage medium have an unfavourable effect on the dissolution characteristics of cements (11, 19).The present study observed higher initial dissolution rate with qahwa drink compared to other selected liquids. Qahwa is a popular and healthy Arabian drink contains many antibacterial and antifungal elements like tryptophan and chlorogenic acid (20, 21). The effect of these components on dental restorative material is unknown necessitating the analysis of the phytochemical components and their action on restorative materials.

Conclusion:

•Cigarette smoke causes dissolution of the resin-modified glass ionomer cement regardless of the period and medium of immersion.

•No cigarette smoke exposure advised directly or indirectly within the initial one-hour placement of resin glass-ionomer dental cements.

•No qahwa drink consumption within one hour of cementation is recommended because of higher initial dissolution in both the control and test groups.

Conflict of interest:

The authors declare that they have no conflict of interest

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