Topographic Effects of Four Different Beverages to Cu-Sn (Eta Prime) Phase Amalgam Surface: A Scanning Electron Microscopic Study

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Abstract

In this study the corroding and/or tarnishing implications of coke, a fizzy soft drink, tea and coffee to the eta prime phase plastic amalgam surface following the filling were evaluated. Thirty six acrylic blocks were prepared which each one was having 5 mm in diameter and 1 mm in depth wells where condensed with amalgam. Those blocks were divided into six groups. The groups were coffee, tea, coke, a fizzy soft drink, water (negative control), and citric acid (positive control). Blocks were immersed into those liquids and were left 5 minutes. Later samples evaluated under SEM (Scanning Electron Microscope). While coke causing mostly pitting corrosion, fizzy soft drink was causing inter granular corrosion, and citric acid caused crack type corrosion. Tea and coffee did not show any effect to topographic structure similar to water to the eta prime phase amalgam.

Keywords: Amalgam; Beverages; Corrosion; SEM

Introduction

The essential structure of traditional amalgam is consisted of Ag-Sn gamma phase (γ) and this phase is the balancing phase of the amalgam and consolidates the hardnes of amalgam. During the amalgamation when the Ag-Hg gamma-one (γ1) and Sn-Hg gamma-two (γ2) phases progressing amalgam is soft and condensable. Increasing crystallization of γ1 and γ2 phases hardens amalgams and the period between soft and hard phases is known as working time [1-2]. During the working time operator is able to manipulate the amalgam and burnish. Following the burnishing the patients are recommended not to eat for a while until the amalgamation terminates. But there are not enough information about the effect of the beverages to soft phase amalgam until hardens in the mouth. Mouth is an electrolytic environment because of saliva and oxygen, chloride, phosphoric, lactic, carbonic, malic, oxalic, tartaric, acetic acid containing beverages besides the humidity and all acidic and alkaline solutions may lead tarnishing and localized corrosion on the surface of the soft amalgam also sulfide in the coffee and tea may cause the same effects. Mostly corrosion is observed at the grain boundary and around dendrites as irregularities also at the amalgam surface [3-5]. Dendrites are Ag rich structures and chloride ions at the media increase the corrosion [6]. High-copper amalgams set in a manner similar to low-copper amalgams except that SnHg reactions are suppressed by the preferential formation CuSn (eta prime) phase’s instead [1]. CuSn phases that are part of the set amalgam matrix are much less corrosion-prone than the SnHg phase they replace. The CuSn phases are still the most corrosion prone ones in the amalgam. However, when they corrode, penetrating corrosion does not occur because individual crystals generally are not connected [1]. Both low-copper and high-copper amalgams undergo two kinds of corrosion, chemical corrosion and electrochemical corrosion. Chemical corrosion occurs most notably on the occlusal surface and produces a black AgS tarnish film. Electrochemical corrosion is an important mechanism of amalgam corrosion and has the potential to occur virtually anywhere on or within a set amalgam [1].

Corrosion is a disintegration of the metal body. Corrosion attacks may cause rapid mechanical failure of a structure even though the actual loss of material quite small. This disintegration of a metal may occur through the action of moisture, atmosphere, acid or alkaline solutions, and certain chemicals [7]. Tarnish is often the forerunner of corrosion. The film that is deposited and produces tarnish may in time form, or accumulate, elements or compounds that chemically attack the metallic surface [8]. For example, eggs and certain other foods contain significant amounts of sulfur. Various sulfides, such as hydrogen and ammonium sulfide corrode silver, copper, mercury, and similar metals present in dental alloys and amalgam. In addition, water oxygen and chloride ions are present in saliva and contribute to corrosion attack. Various acids such as phosphoric, acetic, and lactic are present at times. At the proper concentration and pH these can lead the corrosion [8]. Corrosion is a chemical or electrochemical process through which a metal is attacked by natural agents, such as air and water, resulting in partial or complete dissolution, deterioration, or weakening of any solid substance [8]. Although glasses and other nonmetals are susceptible to environmental degradation, metal are generally more susceptible to such as attack because of electrochemical reactions [8].

The purpose of this study was to evaluate the surface effects of different beverages to the CuSn phase amalgam and observing the corrosive implications of the carbonic acid containing and fizzy soft drinks besides sulphur containing tea and coffee to the amalgam surface and emphasize the importance of not to drink besides not to eat until amalgam completes the amalgamation for the favor of the filling.

Materials and Methods

5 mm diameter and 1 mm in depth wells were operated in six different acrylic blocks and amalgam (Permite C Capsules 1 spill Regular Set, SdI-Australia, Spherical & Lathe-cut, 56% Ag, 27.9% Sn, 15.4% Cu, 0.5% In, 0.2% Zn) was condensed in those wells for each beverage and control groups (totally 36 blocks). Following the burnishing, those acrylic blocks inserted separately into tea, coffee, coke, fizzy soft drink, water (negative control) and citric acid 70% (positive control) groups and the blocks were left 5 minutes. Later those examples evaluated under scanning electron microscope (Jeol SEM-ASID 10) with X 3000 magnification and photographs were taken where the surface corrosion was observed and the topographic effects of those beverages were recorded from the most representative fields.

Results

Based on the pictures taken under electron microscope the topographic effects of the beverages during the CuSn phase amalgamation are presented at the Table 1.

<table>
<thead>
<tr>
<th>Corrosion</th>
<th>Water</th>
<th>Tea</th>
<th>Coffee</th>
<th>Fizzy Soft Drink</th>
<th>Coke</th>
<th>Citric Acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitting corrosion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+ (Figure 3)</td>
</tr>
<tr>
<td>Inter granular corrosion</td>
<td></td>
<td></td>
<td></td>
<td>+ (Figure 2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crevice corrosion (Crack type)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+ (Figure 1)</td>
</tr>
<tr>
<td>No corrosion and Not separated dentrites</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uniform structure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Topographic effects of the beverages during the Cu-Sn phase amalgamation.
“+” Means corrosion was observed.

Especially citric acid which was used as positive control group caused strong crevice corrosion, and crack at the surface was observed (Figure 1), which can be attributed, to the acidic characteristic of the citric acid. Water, which was used as negative control in this study showed uniform structure. Tea and coffee group showed similar topographic structure to water without corrosion and/or tarnish and separated dentrites were not observed. Fizzy soft drink caused intergranular corrosion (Figure 2) and coke caused pitting corrosion (Figure 3).

Discussion
Dental amalgam is a metallic restorative material that is used for direct filling of carious lesions or structural defects in teeth. It is a combination of mercury (liquid) and amalgam alloy (powder), which is composed primarily of silver, tin, and copper [9]. Dental amalgam has been demonstrated to be an effective restorative material that has benefits in terms of strength, marginal integrity, suitability for

large occlusal surfaces, and durability [10]. After a certain lifespan, however, many amalgam restorations need to be replaced or repaired as they are exposed to the physico-chemical challenges of intra-oral conditions [11].

Corrosion causes structural changes inside the amalgam and is regarded as the main reason for marginal fractures at the outline of amalgam restorations [12]. On the other hand, corrosion is regarded as beneficial as it is supposed to be the main factor in reducing marginal leakage over time by deposition of amalgam corrosion products in the marginal gap [13]. It is a very common observation that dentin underneath previous amalgam restorations shows extensive black discoloration. Already in the late nineteenth and early twentieth century, it has been suggested that dentin staining should be caused by the penetration of Ag and Hg ions from the overlying amalgam and deposition of metallic sulfides [14]. Theoretically dentin underneath amalgam restorations can be exposed to a variety of ions and molecules originating from amalgam, oral fluids and pulpal liquid [15].

Traditional amalgams are susceptible to corrosion, with chlorides attacking the gamma-two (γ2) phase [2,16]. Chloride ions in saliva, food and drinks play an essential role in the corrosion process and the deposition of metallic salts. The advent of high-copper amalgams eliminated or reduced the corrosion associated with gamma-two, because the formation of this phase was prevented or retarded and the formation of Cu-Sn (eta prime) occurred instead. Because no Hg is released by the corrosion process in high-copper amalgams, microscopic expansion is prevented, thus reducing marginal fracture potential [14]. However in modern high-copper amalgams, introduced by Innes and Youdelis in 1963, the eta (Cu-Sn) phase is the most corrosion prone phase [17], with the following reaction [2]:

\[
4\text{Cu}_6\text{Sn}_5 + 19\text{O}_2 + 18\text{H}_2\text{O} + 12\text{Cl}^- \rightarrow 6\{3\text{CuCl}_2 \cdot 2\text{Cu}(\text{OH})_2\} + 20\text{SnO}. 
\]

This reaction will not substantially affect the strength of the high-copper amalgam in the margin because the Cu-Sn is not an interconnected phase. However, corrosion of Cu-Sn has raised questions as to possible biocompatibility of the copper-containing corrosion products of high-copper amalgams [2]. Sn, Zn and Cu are the main elements that are involved in amalgam corrosion processes and might be available for penetration into dentin [15]. Except amalgam components also external pigments can cause discoloration of dentin. Under freshly packed amalgam restorations residual carious dentin can be stained if exposed to tea and chlorhexidine in vitro [18]. This demonstrates that external pigments can penetrate via marginal gaps into demineralised (caries affected) dentin.

In our study we evaluated the microstructure breaking effects of four different beverages to Cu-Sn phase amalgam, in another saying “just condensed and clinically plastic amalgam topography changes” to some beverages. Hengtrakool., et al. [19] investigated the effect of acidic agents on surface characteristics of metal-reinforced glass ionomer cement, resin-modified glass ionomer cement, resin composite and amalgam and reported that mango juice produced the greatest degradation effect of all materials tested. Similarly we observe those kinds of beverages breaks the crystallize structure of the amalgam, especially at the surface. Therefore patients should be advised not to drink acidic beverages (especially carbonic acid) right after two hours besides not the chew and function of their teeth. Hengtrakool., et al. [19] concluded that, of the materials evaluated, amalgam and resin composite may be the most suitable for restorations for patients with tooth surface loss.

Microstructure in homogeneities associated with amalgam influence the tarnish and/or corrosion behavior; consequently acidic treatments create less homogeneous microstructure and surface topography. The selectivity of the points or regions where tarnish originates clearly indicates the electrochemical nature of the origin of tarnish [20]. In present study we observed that acidic beverages are negatively influencing the surface of the plastic amalgam right after condensation and burnishing and leading pitting and intergranular corrosion. Patients should not drink acidic and high concentration beverages following the amalgam filling specially during the eta prime phase which that means at the first two hours following the burnishing until amalgam completes its’ eta prime phase.

We were expecting some corrosion with tea and coffee group because of sulfide containing of those beverages but could not be proven. On the other hand some oxidation at the surface was seen. As the authors of this paper we are in believe of findings of this study
clinically consolidates the idea of recommending to the patients not to drink, except water at the first two hours following the amalgam filling.

Conclusions

Coke and fizzy soft drink have corrosive and/or tarnishing effects to the CuSn phase amalgam. Therefore patients should be advised not to drink acid containing beverages following the amalgam condensation during the first two hours until amalgam hardens.

Bibliography


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