THE INFLUENCE OF AN ACIDIC SOFT DRINK ON THE MICROHARDNESS OF DIFFERENT RESTORATIVE MATERIALS

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ABSTRACT

Background and Aim: The aim of the present study was to evaluate the effects of an acidic soft drink on the microhardness of different restorative materials.

Materials and Methods: One hundred twelve restoration samples, twenty-eight in each material group (Ketac Molar, Ketac Nano, Filtek Silorane and Filtek Z250), were prepared. After the baseline microhardness measurement, four experimental procedures were applied daily as follows: Group I, samples were immersed in a cola drink (Coca-Cola) for five minutes over five cycles; Group II, a remineralization agent (Tooth Mousse-GC) was applied as an additional step to the procedure for Group I; Group III, a cola drink was applied once a day for twenty-five minutes; and Group IV, the samples were kept in artificial saliva as a control. Following the treatment procedure (1, 7 and 30 days), the microhardness was re-measured, and the data were statistically analysed (p<0.05).

Results: The microhardness of Ketac Molar could not be measured after cola drink exposure due to surface deterioration. The differences in Ketac Nano in all experimental procedures were significant (p<0.05). In contrast, Filtek Silorane was a unique material that was not affected by cola drink exposure.

Conclusion: Within the limitations of this study, the soft drink influenced the microhardness of the restorative materials tested. Additionally, the highest deleterious effect was found for conventional glass ionomer. A detailed ultrastructural analysis is necessary to complement these results.

Keywords: Acidic Soft Drinks, Cola Drink, Microhardness, Restorative Materials

Submitted for Publication: 02.15.2018  
Accepted for Publication: 06.20.2018
BİR ASİDİK İÇEÇĠN FARKLI RESTORATĠF MATERYALLERĠN MĠKROSERTĠLIĞĠ ÜZERĠNE ETKĠSİ

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ÖZ
Amaç: Bu çalışmanın amacı bir asidik içeceğin farklı restoratif materyallerin mikrosertliğini üzerine etkisini incelemekti.

Gereç ve Yöntem: Her bir materyal grubunda (Ketac Molar, Ketac Nano, Filtek Silorane ve Filtek Z250) yirmi sekiz adet olmak üzere toplam yüzden yüz on iki adet örnek hazırlanıdı. Başlangıç mikrosertlik ölçümü sonrası belirtilen prosedürler günlük olarak uygulandı. Grup I; örnekler beş kez beş dakika kola (Coca-Cola) içerisinde bekletildi. Grup II; Grup I’deki işleme ek olarak bir remineralizasyon ajanı (Tooth Mousse-GC) uygulandı. Grup III; günde yirmi beş dakika kola uygulandi. Grup IV; kontrol grubu örnekleri yapay tükürük içinde bekletildi. Uygulamalar sonrası (1, 7 ve 30 gün) tekrar mikrosertlik ölçümü yapıldı ve veriler istatistiksel olarak analiz edildi (p<0.05).

Bulgular: Ketac Molar grubunda kola uygulaması sonrası yüzey deformasyonu nedeniyle mikrosertlik ölçümü yapılamadı. Tüm deney gruplarında Ketac Nano için farklılık anlamlı idi (p<0.05). Buna karşın kola uygulamasından etkilenen tek materyal Filtek Silorane idi.

Sonuç: Bu çalışmanın sınırları dahilinde, asidik içecekten incelenen restoratif materyallerin mikrosertliğini etkilediği söylenebilir. İlayetin en yüksek hasar geleneksel cam iyonomer için saptanmıştır. Bulguların desteklenmesi için detaylı ultratükenmekte analiz gerekliydi.

Anahtar Kelimeler: Asidik İçecek, Kola, Mikrosertlik, Restoratif Materyal
INTRODUCTION

Over recent decades, dental erosion has remarkably increased in the world population, particularly in developed countries, which is contrary to the decline in caries prevalence. Dental erosion, known as mineral loss on the tooth surface, is an acidic dissolution process caused by acids from something other than bacterial sources. The dissolution not only influences dental hard tissues but also can affect restorative materials due to the acidic conditions and cause erosion in the oral cavity. Many reports have shown that acidic challenge causes degradation in tooth-coloured restorative materials, such as glass ionomer restoratives, polyacid modified resin composites and resin composites.

The external causes of erosion, acidic food and drinks, exist in popular diets, and the relationship between dental erosion and acidic foodstuffs has been reported previously. The total amount and frequency of consumption of acidic food and drinks in the diet has changed with alterations in lifestyle, and cola drinks are one of the most consumed acidic drinks in the population.

Protective approaches against erosion are based on the principle of providing balance between demineralization and remineralization. Fluoride-containing products are the most commonly used preventive agents as reservoirs for remineralization of erosive areas. There is an increasing demand for alternative remineralization agents due to the debate about the side effects of fluoride. In recent years, new products based on casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) have also been introduced as alternative remineralization approaches. There is a necessity for detailed studies of the effects of CPP-ACP on restorative materials as well as erosion of dental hard tissues.

From this point of view, the aim of this in vitro study was to evaluate the effects of cola drink on the microhardness of tooth-coloured restorative materials examining different intake types and time intervals. Furthermore, the effect of CPP-ACP was also evaluated.

MATERIALS AND METHODS

Preparation of Specimens and Microhardness Measurements

Four different restorative materials were used in this study. Overall, one hundred twelve samples, twenty-eight in each material group, were prepared in 6.4 mm diameter and 1.2 mm tall plastic blocks. The restoration materials included in this study and application techniques are listed in Table 1. The specimens were stored in 100% humidity at 37°C for 24 hours. Baseline microhardness measurements were performed using the diamond Vickers microhardness tip (Shimadzu, Kyoto, Japan) with a 50 g indentation load for 30 seconds. Measurements of indentation were carried out on the computer using a software program (Kameram CMOS 122 CU, Turkey) connected to the microhardness device (Shimadzu, Kyoto, Japan) integrated with a digital camera. Three measurements were taken from each specimen. After microhardness measurement, specimens were randomly divided into four groups of seven samples each. Following the cola drink (Coca-Cola, Turkey) exposure as explained in the test procedures part of this article, post-immersion microhardness measurements were performed according to the initial measurement guidelines described above.

Cola Drink Application and Test Procedures

In this study, four experimental procedures were applied, and artificial saliva was chosen as the storage solution for each group. The treatment protocols for the study were as follows:

Group I, samples were immersed in cola drink (Coca-Cola, Turkey) for five minutes over five cycles per day to mimic a medium level of intake;

Group II, after the cola drink application mentioned for the first group, a remineralization agent (Tooth Mousse, GC Dental, Tokyo, Japan) was applied according to the manufacturer’s instructions;

Group III, the cola drink was applied to the samples once a day for twenty-five minutes without any remineralization procedure (negative control); and

Group IV, the samples were only kept in artificial saliva during the experimental period (control group).

The test procedures described for the groups were continued for thirty days. The specimens were immersed in cola drink without agitation, and fresh cola drink from the refrigerator was used each time. The samples were washed with distilled water after the cola drink exposure was completed and then stored in artificial saliva at room temperature. The artificial saliva was freshened every day to provide a constant ion concentration.

Statistical Analysis

In this study, the normal distribution of the data (test of normality) was determined with the Shapiro-Wilk test. The interactions among the test groups in this study were controlled with a repeated-measures ANOVA.
Due to the double and triple interactions, t-tests were used to determine the effects of time on microhardness for each material. Similarly, univariate analysis of variance followed by Bonferroni correction was used to compare the effects of different treatments for the test groups used in this study on the 1st, 7th and 30th days (p<0.05).

RESULTS

The differences among baseline microhardness measurements from each material divided into different application procedures were not significant (p>0.05). At the end of the first day, the only material that was affected by the study protocols was Ketac Molar (p<0.05) (Table 2). Furthermore, the surface deterioration on Ketac Molar did not allow measurement of the microhardness on the 7th and 30th days for all study groups except Group IV, which was the control. Therefore, the comparisons on these days were performed for Ketac Nano, Filtek Silorane and Filtek Z250. When the data from the 7th day were examined, it was observed that the microhardness of Ketac Nano was affected differently from the other protocols study groups (p<0.05). Pair-wise comparisons indicated significant differences among all study groups except Groups I and IV. In addition to Ketac Nano, Filtek Z250 was the other material that was affected by the different study protocols on the 30th day (p<0.05). There were significant differences among all study groups except Groups II and IV for Ketac Nano and Groups I and II for Filtek Z250 (Table 2). However, the only material that was not affected by the study protocols was Filtek Silorane (p>0.05).

Table 1. The restorative materials used in the study

<table>
<thead>
<tr>
<th>Trade name and classification</th>
<th>Manufacturer</th>
<th>Composition</th>
<th>Material form</th>
<th>Light application (LED)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filtek Z250 Universal hybrid composite</td>
<td>3M ESPE, St Paul MN, USA</td>
<td>Filler: 60% (volume), zirconium silica (different particulate diameters with mean 0.19-3.3 µm) Resin: UDMA, BisEMA/TEGDMA</td>
<td>The material was inserted into the mould, which had transparent plastic strips and glass beneath it. The surface of the material was covered with transparent plastic strips and glass, and the polymerization was achieved from either surface.</td>
<td>20 s LOF 15 s HIF (from each surface)</td>
</tr>
<tr>
<td>Filtek Silorane Silorane-based microhybrid composite</td>
<td>3M ESPE, St Paul MN, USA</td>
<td>Filler: 76%, fine quartz particles and yttrium fluoride Resin: Silorane</td>
<td>The material was placed and polymerized as described in detail above for Z250.</td>
<td>20 s LOF 15 s HIF (from each surface)</td>
</tr>
<tr>
<td>Ketac Nano Light-Curing Glass Ionomer Restorative</td>
<td>3M ESPE, St Paul MN, USA</td>
<td>69% filler (weight) Blend including HEMA, VBCP, fluoroaluminosilicate glass, Nanoparticles and Nanoclusters De-ionized water</td>
<td>Two-part paste was packaged in a unit-dose static mix capsule. The capsule eliminates any hand-mixing or mixing equipment required for current glass ionomer capsules. The capsule was opened and placed into a capsule applier, mixed for 10 seconds and dispensed directly.</td>
<td>20 s LOF 15 s HIF (from each surface)</td>
</tr>
<tr>
<td>Ketac Molar Conventional Glass Ionomer</td>
<td>3M ESPE, St Paul MN, USA</td>
<td>Powder: Calcium-lanthanum-fluorosilicate glass, acrylic acid, maleic acid copolymer Liquid: Water, acrylic acid-maleic acid copolymer, tartaric acid</td>
<td>The capsules of the material were mixed in a special mixer at medium rotation speed for 9 seconds after activation. Then, the material was inserted into the templates, which had transparent plastic strips and glass beneath the capsule carrier. The material was covered with transparent strips and glass from the upper surface and held under pressure for 10 minutes.</td>
<td></td>
</tr>
</tbody>
</table>
DISCUSSION

In the oral cavity, tooth structures and restorative materials are exposed to varying environments based on the food and drinks in the diet. In particular, acidic beverages have been reported to be harmful/detrimental for enamel, dentin and restorative materials. In this study, the deteriorating effect of a cola drink on aesthetic restorative materials was examined using microhardness measurements. The effect of CPP-ACP was also tested. Four kinds of restorative materials that are commonly used in dental practice and different erosive conditions were selected. These materials were a universal hybrid composite (Filtek Z250), a silorane-based microhybrid composite (Filtek Silorane), a light-curing glass ionomer restorative (Ketac Nano) and a conventional glass ionomer restorative (Ketac Molar). The results indicated that all restorative materials except for Filtek Silorane had altered surface hardness when exposed to the cola drink. The preventive effect of CPP-ACP on the restorative materials was not clear except for Ketac Nano samples on the 7th day.

In typical oral conditions, individual chewing behaviours and salivary features modify the erosive process. A cola drink was chosen as an erosive agent in this study because it is one of the most consumed soft drinks in modern society and has highly acidic potential. Additionally, this study was designed considering a medium level of cola drink intake. Considering the protective effect of saliva in the demineralization process, the specimens were kept in artificial saliva during application. Apart from saliva, the protective effect of CPP-ACP, which has been reported to reduce demineralization and promote

| Table 2. The microhardness measurements of restorative materials (mean ± SD). |
|-----------------|----------------|----------------|----------------|----------------|
| Baseline        | Group I        | Group II       | Group III      | Group IV       |
| Ketac Molar     | 101.58±6.29    | 102.39±7.02    | 103.00±6.53    | 102.64±6.29    |
| Ketac Nano      | 47.72±2.63     | 48.33±1.64     | 49.49±2.30     | 49.15±2.53     |
| Filtek Silorane | 53.56±1.79     | 52.18±2.82     | 54.45±5.74     | 55.83±3.06     |
| Filtek Z250     | 80.63±3.84     | 78.12±2.75     | 77.14±2.54     | 77.95±2.57     |
| First Day       |                |                |                |                |
| Ketac Molar     | 100.28±7.26    | 107.10±6.89a   | 100.90±7.00    | 94.10±4.39a    |
| Ketac Nano      | 52.29±2.38     | 53.04±2.62     | 53.54±5.48     | 55.17±3.55     |
| Filtek Silorane | 52.12±3.47     | 51.84±3.92     | 55.31±3.01     | 51.97±3.01     |
| Filtek Z250     | 81.30±5.13     | 80.76±2.69     | 80.76±1.87     | 79.07±4.12     |
| 7th Day         |                |                |                |                |
| Ketac Molar     | -              | -              | -              | 90.23±10.67    |
| Ketac Nano      | 44.07±1.52a    | 48.72±1.83a    | 41.37±2.04a    | 45.06±1.80a    |
| Filtek Silorane | 53.28±2.12     | 52.19±2.73     | 52.42±2.16     | 52.47±2.86     |
| Filtek Z250     | 82.13±3.37     | 81.04±2.43     | 81.58±2.35     | 80.35±2.45     |
| 30th day        |                |                |                |                |
| Ketac Molar     | -              | -              | -              | 90.51±5.20     |
| Ketac Nano      | 39.00±1.50a    | 45.58±1.55a    | 35.86±3.01a    | 47.56±0.80a    |
| Filtek Silorane | 53.11±0.81     | 52.26±1.32     | 51.41±1.98     | 51.94±1.26     |
| Filtek Z250     | 79.70±1.87     | 77.42±3.68a    | 72.83±1.82g    | 82.96±2.15f    |

*The different superscripts indicate statistically significant differences (p<0.05).
remineralization in dental hard tissues, on restorative materials was also evaluated. Acids and acidic metabolites play a major role in dental hard tissue loss for both dental caries and erosion. Therefore, the agents used in caries prevention could also work in the prevention of erosion. Although its anti-cariogenic properties are well documented, the effect of Tooth Mousse, which contains CCP-ACP, on erosion is unclear. CCP-ACP is composed of casein-derived peptides that stabilize amorphous calcium phosphate and act as calcium and phosphate reservoirs. In the literature, there are contradictory study findings about the effect of CCP-ACP on both early enamel lesions and erosion. While several studies stated the significant effect of CCP-ACP on promoting remineralization, some others pointed out the unsatisfactory effect of the agent on the remineralization process. In this study, the effect of CCP-ACP on the microhardness of restorative materials was investigated, and only the surface hardness of the resin-modified glass ionomer material within the CCP-ACP group was better than those of the other groups on the 7th and 30th days. Acidic conditions have been reported to degrade tooth-coloured restorative materials. In this study, among the tested restorative materials, the surface deterioration of the Ketac Molar could not be measured after the first day. This finding is consistent with previous studies reporting that glass ionomers can degrade from acid attacks depending on the acidity. On the other hand, another study reported that the microhardness of glass ionomers was not affected by cola drink treatment. However, the cola-drink treatment duration was limited to 10 cycles and 5 seconds in the mentioned study. Our results suggest that Ketac Molar appears to be the most susceptible material to deterioration from cola drinks at a medium level of intake. The microhardness values of Ketac Molar samples immersed in cola drink were higher than those of the control group samples on the first day (Table 2). As the ion movement of glass ionomers is known, this finding may be related to the increased reactivity of the surface after acidic soft drink application. The material could take ions from the Tooth Mousse or saliva after cola drink application. Detailed ultrastructural examinations are necessary to explain this phenomenon, and the potential reactivity still appears insufficient to compensate for the effect of the cola drink on the surface deterioration of Ketac Molar. Although the surface deterioration of the Ketac Molar did not allow microhardness measurement on the 7th and 30th days, the light-curing glass ionomer containing resin, Ketac Nano, did not show surface deterioration limiting microhardness measurement during the study period. These results could be explained by the reduced effect of acid attack on resin structures compared to that on the glass ionomer matrix. Furthermore, the protective effect of CPP-ACP could be determined clearly in the Ketac Nano group. These results suggest the Ketac Nano and Tooth Mousse combined is an alternative for restorative therapy in acidic conditions. In this study, the universal hybrid composite showed microhardness changes only on the 30th day. The silorane-based resin composite was not affected by cola drink application. Our results are consistent with studies reporting that resin composites show higher durability under acidic conditions and that acidic drinks cause only minor changes. Furthermore, the better resistance of the silorane-based resin in acidic conditions may be attributed to the reinforced structural composition of the material. Within the limitations of this in vitro study, it can be concluded that the cola drink influenced the microhardness of the restorative materials tested and that the greatest deleterious effect was found for the conventional glass ionomer. Additionally, CCP-ACP was not superior to artificial saliva. Further studies are still necessary for a detailed ultrastructural analysis to complement these results.

ACKNOWLEDGEMENTS

This study was supported by the Ege University Scientific Research Foundation (2006-Diz-020). We also acknowledge Timur KOSE for statistical analysis.

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