Abrasive Effect of Brushing on Ormocers Following Acid Conditioning

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The purpose of this study was to evaluate the effect of toothbrushing on the surface roughness and microhardness of Admira and Definite following acid conditioning. Half of the samples were either used as controls or brushed for 10 minutes using an electric toothbrush with slurry. The remaining specimens were stored in orthophosphoric acid with a pH of 1.9 for 24 hours and then half were brushed. The surface roughness of Admira and Definite was not significantly affected by storage under acidic conditions. However, the specimens of both materials in the control groups and the ones tested after acidic storage were found to be significantly smoother than the specimens subjected to toothbrushing alone and brushing following acid conditioning. For both materials, significantly higher values of microhardness were obtained after toothbrushing following acid conditioning than toothbrushing alone. Therefore, brushing following acid conditioning significantly affects the surfaces of the ormocers.

Key words: Ormocer, Brushing, Acid

INTRODUCTION

The physical properties of resin-based restorative materials are dependent upon the types of resin matrices, filler particles and resin-filler interface used, and are influenced by the chemical environment and mechanical wear. Characteristics of oral hygiene materials may play a role in abrasion, such as the type of toothbrush, toothbrush abrasiveness, pH level and amount of dentifrice used. Toothbrush abrasion causes esthetic and biological disadvantages in the long term, such as decreased gloss, discoloration and/or staining of the material surface and increased accumulation of dental plaque. Surface roughness can affect plaque retention, periodontal disease and secondary caries.

The low pH levels of acidic foods or beverages may also influence physical and mechanical characteristics of restorative materials. The resin matrix becomes softened when exposed to certain food ingredients. The development of resin composites with regard to formulation changes has mainly focused on filler technology and mechanisms of initiating polymerization. Packable composites are characterized by a high-filler load and a filler distribution that gives them a consistency similar to hybrid composites. However, no fundamental changes have been achieved in monomer systems since the introduction of...
dimethacrylate monomers, in the form of bisphenol glycidyl dimethacrylate, by Bowen in 1962\(^{10,12-15}\). Only in the recent past have packable restorative materials with new types of matrices, ormocers and organically modified ceramics been developed\(^{12}\). The ormocer composite consists of inorganic-organic copolymers and inorganic silanated filler particles\(^{15}\). Multifunctional urethane- and thioether (meth) acrylate alkoxy silanes as precursors to sol-gel have been developed to synthesize the newly designed inorganic-organic copolymers\(^{11,16-18}\). The alkoxy silyl groups of the silane allow the formation of an inorganic Si-O-Si network by hydrolysis and polycondensation reactions, and the (meth) acrylate groups are made available for photochemically induced organic polymerization\(^{16,18}\). After the incorporation of filler particles, ormocer composites can be manipulated by the dentist like hybrid composites\(^{13,15}\). This novel incorporation of inorganic-organic copolymers in the formulation of ormocers allows for the modification of mechanical parameters over a wide range\(^{13,15,17}\). Ormocers are recommended by the manufacturer for use in restorations of all cavity classes in anterior and posterior teeth.

The purpose of this *in vitro* study was to evaluate the effect of toothbrushing on the surface roughness and microhardness of ormocers following acid conditioning.

### MATERIALS AND METHODS

Two ormocers, Admira (Voco, Cuxhaven, Germany) and Definite (Degussa AG, Hanau, Germany) were selected for this study (Table 1). Forty samples of each material were handled according to the manufacturers' instructions and inserted into propylene molds of internal dimensions of 10 mm diameter by 2 mm thickness. The surface of the restorative materials was covered with a Mylar matrix strip and a glass slab. Polymerization of the ormocers was realized by light curing for 40 seconds (Optilux 401, Demetron, Danbury, CT, USA). Following storage for 24 hours in distilled water at room temperature, the surfaces of the samples were polished.

<table>
<thead>
<tr>
<th>Material</th>
<th>Matrix</th>
<th>Fillers</th>
<th>Filler Size in (\mu m)</th>
<th>Filler Content % by Weight</th>
<th>Filler Content % by Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admira</td>
<td>Inorganic-Organic Siloxane Polymers, Bis-GMA, HEMA, UDMA, Organic acids, Aceton, (\text{Fe}_2\text{O}_3), (\text{TiO})</td>
<td>Ba-Al-Borosilicate, Silicodioxide</td>
<td>0.04-0.7</td>
<td>78</td>
<td>56</td>
</tr>
<tr>
<td>Definite</td>
<td>Inorganic-Organic Siloxane Polymers, (Meth)acrylates</td>
<td>Ba-Glass, Aerosils, Apatite</td>
<td>1-1.5</td>
<td>77</td>
<td>61</td>
</tr>
</tbody>
</table>
with medium, fine and superfine aluminum oxide abrasive disks (Hawe/Neos Dental, Bioggio, Switzerland). After each polishing step, specimens were flushed with air-water spray. All specimens were stored in distilled water at room temperature for one week.

Ten specimens of each material were used as controls without any application and another 10 specimens of each material were brushed for 10 minutes with an electric toothbrush (5400 reciprocal turns per minute) (Braun Oral B Ultra Plaque Remover, D 9525, Frankfurt, Germany) and mounted on a specially designed apparatus exerting an evenly distributed application pressure on the surface under a 200 g weight using a slurry (40 ml water and 25 g Signal Plus Carbonate, Lever Elida, Kocaeli, Turkey). The dentifrice contained 0.145% sodium fluoride, 10% sodium bicarbonate, and 16% hydrated silica. The specimens were then rinsed in water. The slurry was renewed for each test group.

Orthophosphoric acid with the same pH value of Coca-Cola (The Coca-Cola Company, Istanbul, Turkey) (pH 1.9) was prepared to simulate the ingestion of an acidic beverage. The remaining 20 specimens of each material were stored in the acidic solution for 24 hours at room temperature and then rinsed with distilled water. Half of these specimens were brushed as previously described.

Surface roughness values were determined using a Perthometer (Perthen M4P, Mahr, Göttingen, Germany). Three traces were recorded on each specimen at three different locations and the average of these three measurements was used as the score for each specimen. Measurements of the surface microhardness were made using a hardness tester (Zwick 3212, Ulm, Germany). Each specimen was subjected to three indentations under a 500-gram load for 30 s at randomly selected areas and the average of these three measurements was calculated. Two-way ANOVA was completed for both materials and test conditions. Since there was a significant interaction between the two factors, one-way ANOVA and Tukey's Multiple Comparison tests were performed for the statistical analysis.

RESULTS

The mean surface roughness values (Ra) and standard deviations of Admira and Definite under the test conditions are presented in Fig. 1. The surface roughness of ormocers was not significantly affected by acid conditioning. However, the specimens of both materials in the control groups and those tested after acidic storage were found to be significantly smoother than the specimens subjected to toothbrushing alone and brushing following acid conditioning (p<0.001).

The mean surface microhardness values (VHN) and standard deviations of Admira and Definite under the test conditions are given in Fig. 2. For both materials, significantly higher values of surface microhardness were obtained after toothbrushing following acid conditioning than toothbrushing alone (p<0.01).
Fig. 1  The mean average roughness values (Ra, µm) of ormocers. Columns with the same letters are not significantly different at p≤0.05 level. Lower and upper case letters were used for Admira and Definite, respectively.

Fig. 2  The mean average microhardness values (VHN) of ormocers. Columns with the same letters are not significantly different at p≤0.05 level. Lower and upper case letters were used for Admira and Definite, respectively.
DISCUSSION

Toothbrushing affects the surface of conventional and microfilled composite resins\textsuperscript{19-21}. Goldstein and Lerner\textsuperscript{1} reported that the surface topography of a hybrid composite resin was altered by routine toothbrushing and brushing with deionized water had no effect on the surface of the material, while the addition of a dentifrice caused surface deterioration. Composite resins are also susceptible to various modes of chemical degradation\textsuperscript{9,22,23}. Attin et al\textsuperscript{24} reported that the abrasion resistance of polyacid-modified composite materials was reduced under acidic conditions.

In a survey conducted in a large urban area in Mexico by Maupome et al\textsuperscript{25}, over half of the 2008 people interviewed indicated that they consumed at least one soft drink per day, while nearly 5% drank between 5 and 10 soft drinks per day. Today beverages, especially colas, which include orthophosphoric acid with a pH of 1.9, are consumed in great quantities in everyday life. The present study was conducted to find out the effect of this dietary habit on the surfaces of ormocer restorative materials.

Instead of an automatic toothbrushing machine, it was preferred to use an electric toothbrush mounted on a specially designed apparatus to simulate the preventive measures taken to maintain oral hygiene by individuals in everyday life.

It was found in the present study that the surface roughness of the ormocers was not affected by acid conditioning. Brushing alone produced significantly rougher surfaces for both materials in comparison to controls. However, comparing ormocers with composite resins\textsuperscript{1,2,9,19,21,24} will presumably cause invalid results because of the diverse chemical structures of composite resins and ormocers. Very few data are available on ormocers and such studies are not comparable with the present study due to methodological differences.

In one of our previous investigations\textsuperscript{26} conducted on the materials stored in distilled water for 1 week, it was found that Admira has a surface roughness similar to that of amalgam, but has a statistically rougher surface than that of a hybrid composite. In terms of microhardness, Admira displayed statistically lower values than amalgam, while the hybrid composite yielded microhardness values not significantly different from those of Admira.

In the present study, toothbrushing alone and brushing following acid conditioning significantly increased the surface roughness of both materials. Storage in orthophosphoric acid for 24 hours significantly increased the surface microhardness of Admira compared to the control group. This may have resulted from the improvement in polymerization through the reaction between the acid and the other radical groups. The microhardness values of Admira and Definite treated with toothbrushing following acid conditioning were significantly higher compared to the values of those brushed in neutral conditions. It is assumed that when erosive and abrasive factors attack together, surface layers of the materials are removed, thus probably denuding subsurface layers with higher microhardness values. However, this assumption should be investigated in further studies.
CONCLUSION

Toothbrushing following acid conditioning significantly affects the surface of the ormocers.

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