Effects of different kinds of beers on the surface roughness of glazed and polished methacrylate and Silorane-based composites: a 1-month study

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Summary

Background: The aim of this *in vitro* study was to evaluate the effect of different kind of beers on the surface roughness of glazed and polished methacrylate- and Silorane-based resin composites after different immersion periods.

Methods: Methacrylate-based resin composites (Tetric N-Ceram, Ceram-X) and a Silorane-based resin composite (Filtek Silorane) were tested in the study. A total of 126 specimens (n=42 for each composite) were fabricated using a cylindrical custom metal mould. Surface roughness measurement was performed using a profilometer at baseline and after a 1-week and 1-month immersion in different kind of beers or distilled water. The results were analysed using repeated measure ANOVA and Tukey's HSD test ($\alpha=0.05$).

Results: Repeated measure ANOVA results revealed that immersion period was a significant factor in the surface roughness of the tested specimens ($p<0.001$). The lowest surface roughness values were obtained with the specimens' polished Optidisc+BisCover LV. Regardless of the polishing systems used, Tetric N-Ceram showed the statistically lowest surface roughness values ($p<0.05$), whereas Filtek Silorane showed the highest surface roughness ($p<0.001$).

Conclusion: The surface roughness values of the tested resin composites were affected by the pol-

ishing procedure used, the exposure time in the solutions and the type of composite resin.

Key words: surface roughness, glaze, beer, methacrylate composite, silorane composite.

Introduction

Nanotechnology has already opened up to dentistry by manufacturing new composites based on nanofillers which generate both aesthetics and mechanics. These nanostructured composites have combined the mechanical properties of "hybrid composites" and the polishing ability of "microfilled composites" (1). Studies showed that lower surface roughness values and better results on longevity were gained after the polishing of these resin composites (2-5).

In the past few years, Silorane-based resin composites have been introduced with highly related oxirane groups and filler particles, which claim to have low shrinkage and less water sorption as a result of better polymerisation (1, 6). Because of the improvement of the types of composite materials, the longevity of restorations is expected to be higher. Not only the aesthetics, but also the physical properties of the restorations should stay stable since the operation day. Considering the dynamic environment of the oral cavity, it is impossible for restorations not to be affected by forces. One of the most important factors for restorations to maintain their physical properties is the polishing procedures. With a high quality of polishing, surfaces become more resistant to wear and staining, thus increasing the longevity of the restoration (7). In addition, plaque accumulation, gingival irritations and unaesthetic appearance of the restorations could be inhibited (7, 8).

The polishing of composites could be done with a wide variety of instruments, including abrasive discs, strips, silicone-impregnated burs, rubberised points and polishing pastes. Although all of these polishing instruments produce a glossy surface on resin composite restorations, it has been reported that the polishing instruments can also leave irregularities on the surface in different degrees (7, 9). To eliminate these irregularities, filling the microporosities and microgaps, surface sealing could be used (10, 11). These materials can easily penetrate through the microcracks and irregularities formed during the finishing and polishing procedures because of low viscosity and wettability characteristics (12, 13). It has been reported that the application of surface sealant material

into the restoration surface provides a more uniform and smooth surface, thereby affecting the longevity of the restoration by enhancing smoothness (14, 15). Besides, some studies have determined the diminishing of the surface roughness of composites in both *in vitro* and clinical conditions (16-18). It may be beneficial to use the surface sealants after restoring composite resins for patients who have excessive erosive habits. Moreover, behavioural factors could cause the surface irregularities of resin composites, such as consumption of staining food and drinking acidic and alcoholic drinks. As healthy living is becoming a popular lifestyle worldwide, many fruit juices have been consumed regularly. Consumption of alcoholic drinks has been thought to have declined with this new concept; however, the rate of beer drinking has increased during the last 3 years. According data, beer is the third most consumed drink all over the world, after tea and water (19, 20). Beers, with their ethanol content and low pH, have been found to change the resin matrix of composites and to cause wear and surface degradation (6, 21). Although, beer is the most consumed beverage in the world, its effect on the surface texture of tooth-coloured restorative materials is very limited. Therefore, this *in vitro* study was mainly aimed at evaluating the effect of different kinds of beer on the surface roughness of glazed and polished methacrylate- and Silorane-based resin composites after different immersion periods. In addition, the related changes on surface roughness depending on the type of beer, type of composite and type of surface treatments would become apparent by this experimental study. The hypothesis tested was that there would be no statistically significant difference in surface roughness among different glazed and polished resin composites after they are immersed in different types of beer following different immersion periods.

Materials and Methods

A total of 126 disc-shaped specimens (8 mm in diameter and 2 mm in thickness) were prepared from two nanohybrid resin composites (Tetric N-Ceram, Ivoclar Vivadent, Schaan, Liechtenstein; Ceram-X, Dentsply, Konstanz, Germany) and a Silorane-based resin composite (Filtek Silorane, 3M ESPE, Seefeld, Germany) using a custom-made stainless steel mould (n=42 for each group). The resin material was inserted into the mould standing on a glass plate with a transparent polyester strip in one increment. Subsequently, the top surface of the resin-filled mould was covered with another polyester strip, and a glass plate was placed onto it. Standard pressure (with a 1 kg weight) was applied on the glass plate for 15 seconds to let the excess resin out from the specimen surface to obtain a flat specimen surface without bubble formation. Following the removal of the weight and the glass plate, the resin material was polymerised with a conventional halogen light curing unit

(VIP; Bisco Inc., Schaumburg, IL, USA) with a light intensity of 600 mW/cm², as measured using a curing radiometer (Hilux Ledmax Light Curing Meter, Benlioglu Dental Inc., Ankara, Turkey) following manufacturer instructions for 20 seconds. The light curing unit tip was positioned perpendicular to the specimens' surfaces, and the distance between the tip and the specimen was standardised using a glass microscope slide (1 mm in thickness). After the removal of the specimens from the moulds, they were numbered, identifying the bottom surface of each with a scalpel. All the specimens were stored in distilled water at 37±1°C for 24 hours for the completion of the polymerisation. Then, the specimens were randomly assigned to three groups (n=42) (TN: Tetric N-Ceram, CX: Ceram-X and FS: Filtek Silorane) and two subgroups [polishing (Optidisc, KERR, California, USA) and polishing + surface sealant application (Glazed) (Optidisc+BisCover LV, Bisco Inc., Schaumburg, USA)]. For the subgroups, seven specimens from each resin composite were randomly assigned. All the materials were used according to manufacturer instructions, and procedures were performed using the same operator in order to eliminate operator-dependent variables. Low-viscosity surface sealant material was applied into the restoration surface after 15 seconds of orthophosphoric acid (Uni Etch-37; Bisco Inc., Schaumburg, IL, USA) application and five seconds of air drying. Thereafter, a uniform layer of surface sealant material (Fortify, Bisco Inc., Schaumburg, IL, USA) was applied over the etched and dried sample surface using a microbrush, which was gently air-thinned for 15 seconds, and then the surface was polymerised for 10 seconds. Compositions and directions for use of all the materials used in this study are shown in Table 1.

In the sequel, the specimens were exposed to immersion regimen. The specimens of each group were immersed into 30 ml of a regular (RB) or a dark (DB) type of beer (Leffe, NV/SA InBev Inc., Belgium) 2 hours a day at cold temperature (~ 4°C). Distilled water was used as control (W). Between the immersion periods, the specimens were kept in distilled water at 37±1°C. The immersion regimen was followed for 1 month.

Surface roughness measurements were performed using a profilometer (Taylor Hobson Surtronic 3, Taylor Hobson Ltd., Leicester, UK) at baseline at the end of 1 week and 1 month. Before each measurement, the profilometer was calibrated against a standard. The surface roughness (Ra) values of each specimen were measured on the centre part in five different directions, and the mean Ra values were determined with a cut-off value of 0.8 mm, a transverse length of 4.0 mm and a stylus speed of 0.1 mm/s.

Statistical Analysis

The relevant significance was approved at p=0.05. Statistical analysis was performed using repeated

Table 1. Materials used in the study.

Material	Type	Composition	Manufacturer	Batch
Tetric N-Ceram	Nanohybrid composite	Bis-GMA, UDMA, TEGDMA, Bis-EMA, 57% of filler: Barium glass, ytterbium trifluoride, mixed oxides and silica dioxide particles (0.04 - 3.0 nm, mean size 0.7 nm).	Ivoclar-Vivadent, Schaan, Liechtenstein	K08783
Ceram-X	Nanohybrid composite	Methacrylate modified polysilane, dimethacrylate resin, 76 wt% of filler; Barium aluminoborosilicate glass, silica nanofiller, PPF (Glass: 1 µm; silica: 0.02 µm)	Dentsply, DeTrey, Konstanz, Germany	0707000986
Filtek Silorane	Silorane-based microhybrid composite	Silorane (3,4-epoxycyclohexylethylcyclopolydimethyl-siloxane, bis-3,4-epoxycyclohexylethylphenylmethyl-silane), Silanized quartz, yttrium fluoride, 76 wt%	3M ESPE, 3M ESPE, Seefeld, Germany	N175794
Optidisc	Polishing Disk	Polyester impregnated with aluminum oxide particles	KerrHawe, Bioggio, Switzerland	4625964
BisCover LV	Glaze material	Dipentaerythritol diacrylate esters, ethanol	Bisco Inc., Iatasca, IL, USA	110001566

measure analysis of variance (ANOVA), factors (polishing system) and beverages (dark or regular beer) affecting the roughness of the surfaces of composites with different formulas. Tukey's HSD test was used to compare the roughness values between groups. All analyses were performed using a commercially available software package (SPSSWIN 17.0, SPSS, Chicago, IL, USA).

Results

Repeated measure ANOVA results (Tab. 2) revealed that immersion period and polishing systems were significant factors in the surface roughness (SR) of the tested specimens ($p < 0.001$). There were no significant differences in surface roughness among the

tested solutions on different resin composites ($p = 0.245$). Evaluating the results in detail, the SR values for every composite used in the study were lower in glazed specimens than polished ones in each solution. The complete results of the tested materials are given in Table 3.

Based on the baseline results, specimens obtained from group TN had the lowest SR values overall. Polished specimens in group DB had the highest SR values (0.13 ± 0.05), followed by groups RB (0.12 ± 0.04) and W (0.11 ± 0.05), respectively. As for the values for group CX, specimens immersed in RB and DB showed exactly the same SR values (0.15 ± 0.04). In other respects, specimens of W showed the lowest SR values (0.13 ± 0.04) in all polishing groups. Group CX had the highest SR values in glazed groups (0.11 ± 0.05). Polished specimens of group FS had the

Table 2. Repeated measures of ANOVA results.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Time	30.917	1	30.917	7658.734	.000
Material	0.266	2	0.133	32.987	.000
Solution	0.011	2	0.006	1.409	.245
Polishing system	0.976	1	0.976	241.781	.000
Material * Solution	0.039	4	0.01	2.408	.048
Material * Polishing	0.061	2	0.03	7.533	.001
Solution * Polishing	0.035	2	0.018	4.386	.013
Material * Solution * Polishing	0.02	4	0.005	1.248	.290

Table 3. Mean values and standard deviations of tested materials in immersion medias.

Material	Immersion period	Distilled water		Regular beer		Dark beer	
		<i>Polished</i>	<i>Glazed</i>	<i>Polished</i>	<i>Glazed</i>	<i>Polished</i>	<i>Glazed</i>
Tetric N Ceram	<i>Baseline</i>	0.11±0.05	0.08±0.04	0.12±0.04	0.07±0.02	0.13±0.05	0.08±0.04
	<i>1 week</i>	0.14±0.06	0.09±0.04	0.14±0.04	0.08±0.03	0.15±0.06	0.10±0.05
	<i>1 month</i>	0.16±0.05	0.09±0.02	0.13±0.13	0.10±0.04	0.18±0.07	0.10±0.04
Ceram-X	<i>Baseline</i>	0.13±0.04	0.11±0.05	0.15±0.04	0.10±0.05	0.15±0.04	0.10±0.04
	<i>1 week</i>	0.13±0.03	0.11±0.05	0.15±0.04	0.12±0.05	0.15±0.06	0.11±0.04
	<i>1 month</i>	0.13±0.03	0.11±0.05	0.14±0.03	0.13±0.07	0.14±0.04	0.11±0.04
Filtek Silorane	<i>Baseline</i>	0.17±0.1	0.1±0.07	0.15±0.07	0.11±0.07	0.16±0.09	0.09±0.04
	<i>1 week</i>	0.17±0.08	0.13±0.15	0.15±0.08	0.14±0.1	0.19±0.12	0.1±0.05
	<i>1 month</i>	0.2±0.1	0.13±0.06	0.16±0.08	0.12±0.07	0.19±0.11	0.13±0.09

highest SR values among all groups. Glazed specimens of RB had the highest SR scores (0.11±0.07), followed by groups control (0.10±0.07) and DB (0.09±0.04), respectively.

Based on the 1-week results of SR values, group FS had the highest values among all polished groups. Specimens of DB in all polished groups had the highest SR values among all immersion medias as well. In TN groups, RB specimens showed slightly better results (0.14±0.04) than W groups (0.14±0.06) in both polished and glazed specimens. In CX groups, specimens of DB had slightly higher results (0.15±0.06) than RB specimens (0.15±0.04). The W group had the lowest scores among polished specimens. In glazed specimens, RB had the highest values (0.12±0.05). In FS groups, polished specimens of DB had the highest values (0.19±0.12). Specimens of the W group showed higher SR values (0.17±0.08) than those of the RB group (0.15±0.08). Comparing the glazed specimens, the DB group had the lowest scores (0.10±0.05).

At the end of 1 month, SR values followed about the same pattern as before. FS groups had the highest values among all polished groups. Regardless of the polishing systems used, TN groups (W, RB and DB) showed the statistically lowest surface roughness values ($p<0.05$), whereas FS groups showed the highest surface roughness values ($p<0.001$).

Discussion

Composites with different formulas in chemical composition are produced commercially. Because of their varying contents, composites have gained different advantageous properties. The surface characteristics of composites are one of the most effective properties which directly affect the longevity of restorations. With the chemical changes happening in the oral environment, degradation of the surface of composite restorations would occur and consequently, a change in the roughness values would be observed (22).

Throughout, all the changes in oral environment, it is crucial for restorations to maintain their surface characteristics. The purpose of this study was to evaluate the surface roughness values of different kinds of composites immersed in different kinds of beer. Water was used as "control" to imitate the wear capacity of saliva and to compare the roughness scores of other groups.

Considering the clinical results of surface roughness, initial plaque accumulation would occur if the values are measured above 0.2 μm (23). Based on a 1-month experiment period, Tetric N-Ceram had the lowest values, while the Filtek Silorane composite had the highest results, which were at the exact threshold level in the study (0.20 μm). Hence, Silorane-based composites were more prone to plaque accumulation than methacrylate-based composites. The hypothesis is rejected based on the fact that the roughness values of Silorane- and methacrylate-based groups showed statistically significant results at the end of the experiment period.

The roughness values of the composites depend on the particle size, type and concentration of the fillers. Larger fillers do cause rougher surfaces than smaller fillers (24). Despite having smaller averaged particles (0.47 nm) than Tetric N-Ceram (0.7 nm) and Ceram-X (1 μm) composites, Filtek Silorane had the roughest surface of them all following by Ceram-X. Then, evaluating the filler concentration, lowest roughness values were shown by Tetric N-Ceram and that could be attributed to its nanosized inorganic fillers with 57% loading. Both Filtek Silorane and Ceram-X are more intensively concentrated (76%) with fillers than Tetric N-Ceram. Even though Filtek Silorane had smaller particles than Ceram-X, silorane had rougher scores, which is consistent with Bansal's (6) and Benetti's (25) studies. However, there are conflicting results on this issue in that some studies (24, 26) claim the opposite or find similar results among composite types (27, 28). The different roughness values of Filtek Silorane and Ceram-X could be due to different types of main inorganic fillers. Filtek Silorane has silanised

quartz as inorganic filler, while Ceram-X has mostly silica nanofillers.

The surface roughness of a composite depends on not only the inner structures but also the polishing procedures done following restoration (28). In this study, Optidiscs were used for polishing, and a surface sealant, BisCover LV, was used to glaze the specimens after the polishing system. One of the main reasons of manufacturing these low-viscosity surface sealants is that they have the ability to cover up micro porosities and to complete surface integrity (10). Based on the results at every time period, the glazed groups of all composites had lower roughness values than the polished groups. It is certain that glazing did achieve better surfaces in this study, whose results corroborate with those of dos Santos's studies (17, 18). Regardless of the composite type, it is revealed that glazing had a significant role in correcting surface irregularities and had a better performance than polishing procedures.

Evaluating the effects of different kinds of beer on composites was one of the purposes of this study. Two types of beer from the same company (Lefebvre, NV/SA InBev Inc., Belgium) were used to standardise the manufacturing properties. Distilled water was included as "control" just like in many studies (6, 25, 29). Although, groups immersed in water of methacrylate-based composites had smoother surfaces than beer groups without any statistically difference, the water group of Silorane-based composites had roughness scores between dark and regular types of beer. The results could be attributed to differences in the chemical composition of the composite groups or possible inabilities of an *in vitro* experiment.

Based on the 1-month results, groups immersed in dark beer had higher roughness values than groups immersed in regular beer. This may be caused by the physical properties of the beers. The effects of alcoholic drinks on composite materials were obvious, in which ethanol concentration causes disassociation of substances from the surface. Water absorbance of the materials could cause plasticisation of organic matrices and accelerate decomposition. Also, ethanol has directly penetrated through the resin matrix, broken down the polymeric structure (25), separated the bonding between the filler and displaced the filler particles finally resulting in inferior mechanical properties of the composites (22), which could be more important than prolonged immersion in water. The alcohol concentrations of regular and dark beer were nearly the same, 6.6 and 6.5%, respectively. The hydrogen ion concentrations (pH) of beverages could cause the erosion of polymers and initiate surface degradation as well. Although the types of malts have been changed in order to identify beers as "regular" (light malt) and "dark" (roasted malt), alcohol concentration and pH values (4.43 and 4.22, respectively) are similar. This could be the reason of no statistically significant roughness values resulted between beer types. Studies on the effects of beers on surface roughness are lacking. Beers are thought to have a colorant ef-

fect; besides, their alcoholic content is mostly missing. Meanwhile, a study (6) on the effects of whisky on composites was evaluated and yielded results parallel to the results of our study. In a study collaborating with our results (22), the effects of alcoholic beverages on surface roughness of different types of composites have compared and beer had found to change the surface roughness the most after following whisky in 1 month. The attributed changes were, likewise in our study, thought to be related with the low pH (4.1) of the related beer. Further studies are needed to investigate the effects of beers on other physical properties of composites. As the present study is processed in *in vitro* situations, the effect of the cleaning property of saliva is missing. Moreover, oral habits that may enhance permanent forces on teeth and restorations such as tooth brushing may alter the surface properties as well. It is obvious that the present study is limited to *in vitro* situations.

Conclusion

The surface roughness values of the tested resin composites were affected by the polishing procedure used and the type of composite resin. Silorane based composites had statistically inferior roughness scores than nanohybrid composites. Moreover, glazing procedure had better surface characteristics than only-polished samples. When choosing the optimum composites, it should be taken into consideration that, drinking habits could irruptive effect on the surface characteristics. Therefore, dietary anamnesis should also guide when selecting the material type and deciding on using polishing systems.

Even though the present study provides only 1-month results, it emphasises the differences between Silorane- and methacrylate-based composites and highlights the performance of glazing procedures and the effects of different types of beer on surface roughness. The effects of longer immersion periods should be recorded, and additional methods, such as atomic force microscopy, may be used in further studies to detect surface irregularities in detail.

Conflicts of interest

None declared.

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