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Surface Roughness of Resin Composites after Wearing with Toothbrush

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Abstract: ***Objective**: evaluate and compare the surface roughness of two different nano-hybrid composites composite before and after tooth brushing simulation. **Materials and Methods**: Twenty dimensionally standardized composite specimens of two nano-hybrid resin composites (TetricEvoCeram and Admira Fusion) were used. Ten specimens from each composite group. All specimens were polished and then subjected to a tooth brushing simulator wear test. Surface roughness (Ra) were measured before tooth brushing and after 5000, 10, 000, 15, 000, and 20, 000 tooth brushing cycles. The data was analysed using two-way ANOVA to assess surface roughness values and pair wise comparisons in the form of Tukey post hoctests were performed to interpret main effects. **Results**: For all tested materials, surface roughness increased after tooth brushing wear test. Surface roughness (Ra) values ranged from 0.17 to 0.22 µm at baseline and increased to between 0.44 and 0.49 µm after 20, 000 tooth brushing cycles. The lowest initial Ra value was detected in TetricEvoCeram. **Conclusions**: Simulated tooth brushing wear led to an increase in surface roughness for all tested composite materials. TetricEvoCeram had smoother surface after polishing and following 20, 000 cycles of tooth brushing wear whereas, Admira Fusion demonstrated rougher surface before and after tooth brushing abrasion.***

Keywords: dentistry, restorative composite materials, wear, tooth brushing, surface roughness

1. Introduction

Currently, the use of resin-based composites (RBCs) is spreading widely due to their satisfactory aesthetics, preservation of the tooth structure, low cost and good mechanical properties (1). It became the natural choice for dental restorations in regular dental practice (2, 3). Resin composite materials are available in different matrix formulations and filler types that affect both the handling characteristics as well as, physical properties (4, 5). Wear of resin composites in the oral environment caused by both masticatory stresses and toothbrush abrasion have concerned many practitioners as well as, researchers. Daily tooth brushing leads to changes in the surface condition of composite material (6).

Surface characteristics, such as surface roughness considered one of the most important features when selecting a restorative material. Plaque accumulation, discoloration, wear, and appearance of direct and indirect restorations are significantly affected by surface texture of the restorative material itself (4). Moreover, a smooth surface increases patient comfort as any change in surface roughness between 0.30 µ and 0.50 µ can be detected by the tip of the tongue (7).

Rough surfaces of the composite material caused by tooth brushing increase the accumulation of dental plaque and decrease the gloss of the composite restoration (6). Surface texture measurements play an important role in the understanding of how a material will stain or wear in vivo. An important factor in the clinical performance of a material is how it responds to oral hygiene measures such as tooth brushing (8).

There are a great number of resin composites based on conventional monomer systems such as Bis-GMA, UEDMA, TEGDMA, and Bis-EMA (9). This study was therefore undertaken to compare the initially achieved surface roughness values following multiple cycles of tooth brushing abrasion of two composite materials, Admira Fusion; a nano-hybrid Ormocer based composite (Voco, Cuxhaven, Germany) and TetricEvoCeram; a nano-hybrid DMA based composite (IvoclarVivadent, Schaan, Liechtenstein). These composite materials were selected based on their difference in resin matrices with the same filler type and close similarity in filler loads which will allow a comparison of the effect of different resin matrix compositions on surface characteristics while taking into consideration the filler effect.

The aim of this in-vitro study is to evaluate and compare surface roughness of two resin composite materials before and after toothbrush wear.

2. Materials and Method

Two resin-based composite materials were selected with single shade (A2) and divided into two groups each group contain 10 specimens. Group I: TetricEvoCeram (TEC) (IvoclarVivadent, Schaan, Liechtenstein, batch no W10431): based on dimethacrylate and Bis-GMA and Group II: Admira Fusion (AD) (Voco, Cuxhaven, Germany, batch no 1905236): according toormocer as an example of a non-DMA group. All specimens (n=20) and their bonding systems were utilized according to the manufacturer's instructions by compacted and cured each specimen in increments using gold-coated plastic filling instruments in the custom-made silicon mold placed on a glass slab of 1-2 mm. A Mylar transparent strip was placed on the top of each composite material and a glass slide was placed on it with pressure applied to it before curing. After light curing each sample using Elipar S10 LED (3M ESPE, St. Paul, MN, USA) they were finished immediately with a superfine diamond grinder (25 µm) attached to a high-speed hand piece at 200, 000 rpm under water cooling systems.

The polishing procedure was performed using polishing discs (3M ESPE Dental Products, St. Paul, MN, USA) with coarse, medium, fine, and super-fine grits utilized with a low-speed hand piece at a speed of 12, 000 rpm with a constantly moving repetitive stroking action for 30 seconds. To achieve smooth and glossy surfaces and to create identical specimens with standardized baselines, each specimen was polished with a newset of Sof-Lex discs. After the process of polishing, all specimens were cleaned for five minutes using an ultrasonic water bath (Ultrasonic cleaner L & R 2014, Kearny, NJ, USA).

Wear testing was performed using programmable logic-controlled equipment ROBOTA (Model ACH-09075DC-T, AdTech Technology Co. Ltd., Neu-Isenburg, Germany). ROBOTA chambers where each chamber consists of an upper Jackob's chuck brush antagonist holder that can be tightened with a screw and a lower plastic sample holder in which the specimen can be embedded. Regular-headed toothbrushes (Oral-B 40 indicator, regular, Oral-B Laboratories, London, UK) were attached to the simulator holder and the toothbrush was placed parallel to the specimen with the bristles in contact with the composite specimens. A commercial toothpaste (Colgate Total, Colgate-Palmolive, Guildford, UK) was mixed with water to prepare a thin or fluid mud (slurry) according to ISO/TS 1469-1 (2: 1, water: toothpaste). The slurry was poured into the tooth brushing station machine and replaced for every four new specimens. The appealed load during simulated tooth brushing was 2.5 N as per the ISO standard specification (ISO 2813, 2014). A horizontal cross-tooth brushing technique was appealed to each toothbrush head. A counter that attached to the machine counted the number of movements at a speed of 78 cycles per minute. All specimens underwent 20, 000 cycles. The surface roughness was measured after 5000, 10, 000, 15, 000, and 20, 000 cycles. Following each cycle of tooth brushing simulation and before surface roughness was obtained; specimens were cleaned in an ultrasonic water-bath (Ultrasonic cleaner L & R 2014, Kearny, NJ, USA) to remove any potential slurry debris.

All specimens were checked for surface roughness (Ra) before and after toothbrush simulation sing a three-dimensional (3D) optical profilometry surface analyzer system. The Ra value was measured with a 3D optical profilometry surface analyzer system (USB Digital Surface Profile Gauge, Scope Capture Digital Microscope, Guangdong, China), and the data were collected by using the roughness tester supplier software (ElcoMaster version 2.0, Elcometer Instruments, Manchester, England). For all the reading made, the mean Ra value (measured in µm) was measured by the difference between the peaks and valleys registered after the needle of the profilometer scanned a stretch of 2 mm in length, with a cut-off of 0.25 mm. Each surface was scanned three times, starting from three different points and always ending with the needle scanning the center of the specimen. The mean value of the three readings produced the mean value of the roughness of each specimen.

Statistical analysis

Numerical data were explored for normality by checking the distribution of data and using test of normality (Kolmogorov-Smirnov and Shapiro–Wilk tests). Two-way analysis of variance (ANOVA) was used followed Tukey test for pairwise comparison when ANOVA test was significant. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with Statistical Package for the Social Sciences software, version 20.0 for Windows (IBM, New York).

3. Results

(Table 1) shows the mean values of surface roughness for the materials before and after different number of cycles of tooth brushing test. The results before tooth brushing test showed statistical difference between the two composites, where Admira Fusion (AD) composite presented values of surface roughness that were statistically superior to the TetricEvoCeram ($p<0.05$). Following tooth brushing test all materials resulted in significant increase in Ra values. However, after 20, 000 cycles of tooth brushing test, the overall Ra mean for Admira Fusion (AD) was not significantly different from TEC. This was confirmed by pairwise comparison and Tukey post hoc tests.

Table 1: Means and Standard deviations of Ra values in µm for the composite materials after different numbers of tooth brushing cycles

Material	0 Cycle	5000 Cycle	10000 Cycles	15000 Cycles	20000 Cycles	Mean
TetricEvoCeram	0.16± 0.01	0.36±0.03	0.31±0.08	0.40±0.05	0.43±0.06	0.33±0.08
Admira Fusion	0.21±0.01	0.38±0.05	0.48±0.1	0.48±0.10	0.48±0.08	0.41±0.13
Mean	0.17± 0.03	0.36±0.04^{b}	0.40±0.10$^{a, b}$	0.41± 0.10^{b}	0.44±0.07^{a}	

n = 10 specimens per group. Mean surface roughness values that are not significantly different are indicated by the same lowercase superscript letter (post hoc analysis Tukey HSD p > 0.05).

4. Discussion

The surface roughness any resin composite material the products of the interaction of several factors; intrinsic and extrinsic. The intrinsic factors are related to the material itself such as, type of resin matrix, the filler (type, size, and distribution of the particles) and the effectiveness of the bond at the interface between filler\resin (10). Extrinsic factors are related to the type of polishing system used and the light-curing method (10, 11). In the current study, the polishing system and light-curing method were standardized for all the tested materials, and all tested materials were nano-hybrids with their filler loadings being similar to each other.

Both resin matrix and filler particle type are thought to affect surface condition after tooth brushing due to selective abrasion of the resin matrix as well as, the dislodgment of filler particles caused by long-term use (6). The increase in surface roughness is the mean cause for an undesirable loss of esthetics of the restoration, due to the loss of surface gloss and biological disadvantages (6), causing dental plaque accumulation and increasing the risks of dental caries and periodontal inflammation (12).

All tested materials contained nano-hybrid particles that combined nanometric and conventional fillers with a comparable average particle size. The resulted analysis of this study before wear test showed no significant difference between both tested group although, Admira Fusion had a higher Ra values before toothbrush test than TetricEvoCeram. It was thus expected that they would show comparable surface roughness (Ra) values following the polishing procedures. However, variations in Ra values were found, which could be related to the fact that TetricEvoCeram (TEC) had a relatively lower filler content by weight (78–80%) compared to Admira Fusion (AD) which had an 84% filler content by weight (15).

Simulated tooth brushing wear test significantly affected surface roughness. For both tested composite materials, surface roughness significantly increased with no significant difference between both groups; Admira Fusion (AD) and TetricEvoCeram (TEC) following the 20, 000 cycles of tooth brushing wear test which is corresponding to 4–7 years of tooth brushing (6). This agreed with another study that compared surface roughness before and after tooth brushing wear test of different composite systems (16).

Thus, the number of cycles used in this study (maximum of 20, 000 cycles) was not enough to produce a roughness that would bring disadvantages from an esthetic and biological standpoint. However, in an in vivo situation, variables other than tooth brushing can cause wear of the composites. For example, temperature changes can cause tensile stress in the restoration, because of differences in the thermal expansion coefficients between the matrix and the filler (13, 14). Occlusal wear may also cause loss of material during mastication (14). All these parameters may modify the values of surface roughness found. Subsequently, further investigations are still necessary to predict the effect of tooth brushing wear in composite restorations.

5. Conclusion

Tested nano-hybrid composite materials based on methacrylate resin and its derivatives show acceptable surface roughness characteristics of its surfaces after being subjected to repeated cycles of abrasion wear.

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Conflicts of interest
There are no conflicts of interest.

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