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EVALUATION OF SURFACE ROUGHNESS OF DIFFERENT DENTAL RESIN COMPOSITE, COMPARATIVE INVITRO STUDY

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ABSTRACT:

Aim of the work: The aim of this study is to compare surface roughness (Ra) of nanohybrid, nanofilled, fiber reinforced and bulk fill composites. Materials and methods: Testing procedures was done according to ISO 25178-2:2012. Ten specimens of GrandioSo, Filtek™ Z350 XT, Ever X Posterior and Beautifil-Bulk were prepared in a half-split stainless-steel round mold of 8 mm diameter and 2 mm thickness. Specimens were sequentially finished with a 600# and 1,200# silicon carbide paper, then were polished sequentially with a complete series of Soflex polishing discs. Surface roughness was measured by optical (Profilometry) without contact. Statistical analysis was made by SPSS Statistical Package of Social Science version 25. Results: The highest surface roughness (μm) mean value was recorded for Ever-X Posterior (1.15 ± 0.2 m) followed by Beautifil-Bulk (0.188 ± 0.009μm), then GrandioSo (0.170 ± 0.009 μm). The lowest mean value was recorded for Filtek™ Z350 XT (0.095 ± 0.005μm). One-Way ANOVA revealed that, there was significant difference in surface roughness between tested composite materials (P=0.000). Conclusion: Within the limitations of this study, internal structure of composite resin as types of resin matrix, size and types of composites filler affect the surface morphology of resin composites.

KEYWORDS: Surface Roughness, Resin Matrix, Composite Filler, Profilometry, Aesthetic Dentistry.

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INTRODUCTION

The ultimate esthetic properties of tooth-colored restorative are greatly influenced by the final surface polish. The esthetic success of a restoration is directly related to its optical appearance. Surface roughness, surface gloss, and color are among the most important factors in the perceived visual effects of resin composite restorations. Correlations among these factors might differ by resin composite and shade [1,2].Surface roughness is defined as the finer irregularities of a final restoration which are a result of the configuration and manufacture of the material [3].In vivo studies of surface roughness (Ra) have shown that there was a substantial increase in bacteria retention above a threshold of 0.2 μm [4]. In addition, roughness was positively correlated with accumulation of dental plaque and might also be related to differences in surface properties such as gloss retention and color stability [5,6].

Finishing and polishing procedures require sequential use of instrumentation with gradually smaller grained abrasives in order to achieve the desired glossy surface [7]. Proper finishing of restorations is desirable not only for aesthetic considerations but also for oral health. The primary goal of finishing is to obtain a restoration with good contour, occlusion, healthy embrasure forms and a smooth surface [8,9]. Tight margins should blend aesthetically into the tooth's natural contours, and resin composite restorations should be smooth so as to reduce plaque retention and minimize possible gingival irritation, surface staining, patient discomfort and recurrent decay [10]. In the market, dental resin composites are available in various types, primarily differentiated by their filler particle size, shape and incremental thickness e.g., nanohybrid, nanofilled, fiber reinforced and bulk fill composites [11, 12]. Various techniques can be used for assessing surface roughness [13]. Research on surface roughness in dental materials has involved qualitative methods such as optical and scanning electron microscopy and quantitative methods [14], such as surface profile analysis. Contact diamond and non-contact laser modes as well as laser reflectivity measuring systems are commonly applied for surface profile measurements [15]. The Profilometry test is available and simple test for measuring the surface roughness of a composite restoration [16]. Aim of this study is to compare surface roughness (Ra) of nanohybrid, nanofilled, fiber reinforced and bulk fill composites. Null hypothesis there is no significant difference in surface roughness (Ra) between different composite type.

Materials and Methods:

Table1 represents the restorative materials that were evaluated. The restorative materials were handled according to the manufacturer guidelines, and all specimen's preparation procedures were accomplished by one operator.

Table (1): Specifications of tested resin composite

Commercial Name	Composite Type	Manufacturing	Chemical composition / Filler loading (wt %)
GrandioSo	Nanohybrid	Voco, Cuxhaven, Germany	Matrix:Bis-GMA, Bis EMA,TEGDMA Filler: glass ceramic fiber, functionalized silicon dioxide nano particles (89%)
Filtek™ Z350 XT	Nanofill	3M ESPE, St Paul, MN, USA	Matrix: Bis-GMA, UDMA, Bis-EMA, TEGDMA Filler: silica nanofiller (5–75 nm), zirconia/silica nanocluster (0.6–1.4 µm) (72.5%)
Ever-X Posterior	fiber reinforced bulk fill	GC, Tokyo, Japan	Matrix: Bis-GMA, TEGDMA, TEGDMA Filler: short E glass fibers filler, barium glass (74.2%)
Beautifil-Bulk	Bulk-fill resin composite (high viscosity	Shofu, Kyoto, Japan	Matrix: Bis-GMA, TEGDMA, pigment, photoinitiator, S-PRG: surface reaction type pre-reacted glass ionomer with fluoro-aluminosilicate glass (0.01–4 µm) (87.0 wt%, 74.5 vol%).

materialsTesting procedures was done according to ISO 25178-2:2012 [17]. Ten specimens of each composite were prepared in a half-split stainless-steel round mold of 8 mm diameter and 2 mm thickness. Mold was put on a glass slide covered by Mylar strip and separating medium was applied to mold's wall with a brush, then composite materials were applied to the mold cavity according to manufacture guidlines. After that, glass slide covered with Mylar strip was put the top of the mold. Curing was carried out on the top then on the bottom of the specimens before removal from the mold. Curing was achieved by light-emitting-diode LED curing unit for 20 sec with four overlapping light exposures to cure the entire length of specimen.Once specimens cured mold was opened and composite excess was removed, specimens were sequentially finished with a 600# and 1,200# silicon carbide paper, then were polished sequentially with a complete series of Soflex polishing discs (3M ESPE, St Paul, MN, USA). For standardization a single operator, using a low-speed handpiece at approximately 4,000–5,000 rpm, performed the polishing procedure. After that, the polished surfaces were water-rinsed with an air-water syringe for 60 secs, to remove any surface debris left and then specimens were cleaned in ultrasonicator (Power sonic 405, Hwashin Technology Co, Korea). (Figure 1)

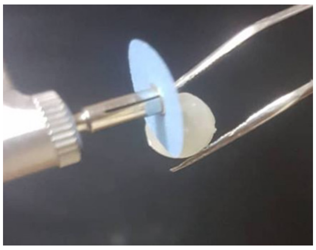

Figure 1: Specimen polishing by polishing disc.

The optical methods (Profilometry) tend to fulfill the need for quantitative characterization of surface topography without contact. Each specimen was photographed using USB Digital microscope with a built-in camera (Scope Capture Digital Microscope, Guangdong, China) connected to an IBM compatible personal computer using a fixed magnification of 120 X (Figure 2). The images were recorded with a resolution of 1280 × 1024 pixels per image. Digital microscope images were cropped to 350 x 400 pixels using Microsoft office picture manager to specify/ standardize area of roughness measurement. The cropped images were analyzed using WSxM software

(Version 5 develop 4.1, Nanotec, Electronica, SL). Within the WSxM software, all limits, sizes, frames and measured parameters were expressed in pixels. Therefore, system calibration was done to convert the pixels into absolute real-world units. Calibration was made by comparing an object of known size (in this study a ruler was used) with a scale generated by the software. 3D images were collected for each specimen, in the central area and in the sides at area of 1 µm × 1 µm. WSxM software was used to calculate the average of heights (Ra) expressed in µm, which was assumed as a reliable index of surface roughness.

Figure 2: USB Digital microscope with a built-in camera and connected with an IBM compatible personal computer

Statistical Analysis: The data were collected and tabulated and statistically analyzed by an IBM compatible personal computer with SPSS Statistical Package of Social Science version 25 (SPSS Inc. IBM SPSS statistics for windows, version 25.0, Armnok, NY: IBM Corp.). Two types of statistical analysis were done:

1. Descriptive statistics was expressed in mean ($\bar{x}$) and standard deviation (SD).
2. Analytic statistics: One-way ANOVA was used to determine statistical significance between groups and post hock test (Tukey' Kramer) was used for multiple comparisons, if there was significant difference between any 2 groups.

- P- value of < 0.05 was considered statistically significant.

Results

Surface roughness(µm)means and standard deviations of all tested composite are present in Table (2) and shown in Figure (3). The highest surface roughness (µm) mean value was recorded for Ever-X Posterior (1.15 ± 0.2 µm) followed by Beautifil-Bulk (0.188 ± 0.009 µm), then GrandioSo (0.170 ± 0.009 µm). The lowest mean value was recorded for Filtek™ Z350 XT (0.095 ± 0.005µm).

Table 2: Surface roughness (µm) means and SDs of all tested composite materials.

Composites	Mean ± SD (mm)
GrandioSo	0.170 ± 0.009 ^{a}
Filtek™ Z350 XT	0.095 ± 0.005 ^{a}
Ever-X Posterior	1.15 ± 0.2 ^{b}
Beautifil-Bulk	0.188 ± 0.009 ^{a}

Means with the different small superscripted letters demonstrated statistically significant differences ($p \leq 0.05$).

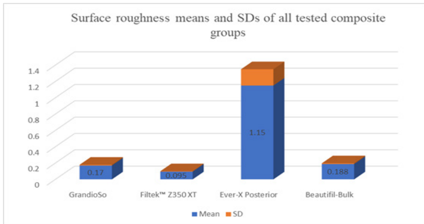

Figure (3): Surface roughness (mm) means and SDs of all tested composite materials.

One-Way ANOVA revealed that, there was significant difference in surface roughness between tested composite materials (P=0.000) (Table 3).

Table 3: One way ANOVA of surface roughness (mm) of all tested composite materials.

ANOVA OF SURFACE ROUGHNESS					
	Sum of Squares	df	Variance	F	P value
Between Groups	7.5337	3	2.5112	249.9537	0.000

The mean difference is significant at P < 0.05.

Multiple comparison Post hoc (Tukey's) test revealed that was no significance difference in surface roughness between GrandioSo and Filtek™ Z350 XT (p = 0.3523), also, there was no significance difference in surface roughness between GrandioSo and Beautifil-Bulk (p = 0.9778) but GrandioSo was significantly lower than Ever-X Posterior (p = 0.0086).Ever-X Posterior was significantly higher than Filtek™ Z350 XT (p = 0.0466) and significantly higher than Beautifil-Bulk (p = 0.0050).Post hoc (Tukey's) test revealed that was no significance difference in surface roughness between Filtek™ Z350 XT and Beautifil-Bulk (p = 0.1808).

Discussion

The surface quality of resin composite restorations is one of the most important factors determining their esthetic and biological clinical success. Daily, the surfaces of resin composite restorations are directly exposed to degradation by biofilm attack, acid erosion, water sorption, occlusal and thermal stresses, and/or enzymatic degradation [18,19].In present study, finishing and polishing system and procedures were standardized to exclude these important factors because finishing procedures have a high impact on the surface roughness of composites [20-22]. Early studies have shown that the smoothest surface of a restoration is attained when the resin is polymerized against an appropriate matrix strip [23]. When such a matrix is not used, polymerization of the outer layer is inhibited, resulting in a surface layer rich in organic binder,which has a stickier, softer consistency[24, 25]. Since such a finish cannot be maintained, further contouring and finishing are required. Finishing is the gross contouring of a restoration to obtain desired anatomy, while polishing refers to reduction of the roughness and removal of scratches created by finishing instruments [26, 27].In current study, Ever-X Posterior has high surface roughness this could be attributed to: (i) filler is composed of short E glass fibers filler which is large in size during finishing they can protrude from the resin leave large roughness [28,29]. (ii) presence of hydrophilic monomer (TEGDMA) which increased water absorption leading to swelling and potentially increasing surface roughness. Also, hydrophilic monomer can undergo hydrolysis and degradation, breaking down the polymer matrix and leading to increased surface roughness. Finally, it can make the composite more susceptible to wear, potentially leading to increased surface roughness over time [30-33]. Results of this study revealed Filtek™ Z350 XT was the lowest surface roughness this is due to: (i) Small particle size: Nano cluster fillers have a small particle size, typically in the range of 1-100 nanometers. This small size allows for a more uniform distribution of particles, reducing surface roughness [34]. (ii) The small size of nano cluster fillers reduces the likelihood of filler particles protruding from the surface, contributing to a smoother surface finish [35,36]. (iii) Type of resin also affect surface morphology, i.e. increase hydrophobicity of resin as in urethane dimethacrylate (UDM) based matrix led to low water sorption, less surface degradation and finally composite surfaces have to be polished to reduce the risk of gingival irritations, surface staining, patient discomfort and the formation of secondary caries[37-38].Statistical analysis revealed that, there was significant difference in surface roughness between tested composite materials therefore, the null hypothesis was rejected.Surface roughness results in current study are in consistence with Zortuk et al., [39] who found that the reinforcement of provisional crown and fixed partial denture resin with different percentage of glass fibers. In consistence with current study, when exposed to tooth-brushing in experiments, mostnano-hybrid and micro-hybrid composites maintain a surface roughness below 0.2µm, which is considered to be the threshold for plaque retention [40]. But surface roughness of fiber reinforced Ever-X Posterior 1.15µm so that, it must be covered with another nanocomposite.

Conclusion

The internal structure of composite resin as types of resin matrix, size and types of composites filler affect the surface morphology of resin composites.

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