Effect of Different Finishing and Polishing Systems on the Surface Roughness of Composite Resins

ADRIANA BALAN[1], ANDREI-VICTOR SANDU[2,3], SIMONA STOLERIU[1]*, VERONICA SERBAN PINTILICIUC[1], VASILICA TOMA[1]

[1] „Grigore T. Popa" University of Medicine and Pharmacy of Iasi, Faculty of Dental Medicine, 16 Universitatii Str., 700115, Iasi, Romania

[2] „Gheorghe Asachi" Technical University of Iasi, Faculty of Materials Science and Engineering, 53A D. Mangeron Blvd., 700050, Iasi, Romania

[3] Center of Excellence Geopolymer & Green Technology (CEGeoGTech), School of Materials Engineering, Universiti Malaysia Perlis, 01000 Kangar, Perlis Malaysia

The aim of the study was to compare using atomic force microscopy the surface roughness of three types of composite resins after finishing and polishing procedure with three different systems. A hybrid (Valux Plus, 3M ESPE), a microhybrid (Filtek Z 250, 3M ESPE) and a nonohybrid (Herculite XRV Ultra, Kerr) composite resins were chosen for this study. A number of 28 samples having 10 mm in long ,7 mm in width and 2 mm in high of each composite resin were obtained. The samples were equally split in 4 groups. In control group 7 specimens of each material received no finishing and polishing treatment after being cured under plastic matrix strip. In the first study group 7 samples of each material were finished using fine, safe end taper tungsten carbide bur, 7 samples were finished using superfine needle diamond bur and 7 samples used diamond impregnated one stage polisher. The surface of all composite samples was analyzed using atomic force microscopy. The results were expressed as root mean square surface roughness (nm). The results were statistically analysed using ANOVA and post hoc Bonferroni test at a 0.5 significance level. Significantly differences were obtained in the surface roughness of all three tested composite resins after finishing and polishing when comparing to surface roughness from control group. The one-step diamond abrasive polisher leaded to a significant lower surface roughness for all three composite resins when comparing to the surface roughness when tungsten carbide bur or diamond bur were used. Surface roughness of Valux Plus was higher than that observed for Filtek Z 250 or Herculite XRV Ultra, irrespective of the system used for finishing and polishing. The surface roughness of composite resins is in relation with the type of composite resin and the type of finishing and polishing system. The one-step diamond abrasive polisher was more efficient in obtaining smooth surface when comparing to tungsten carbide bur or diamond bur. The nanohybrid composite resin has a lower surface roughness when comparing to microhybrid and the hybrid composite resin after finishing and polishing.

Keywords: composite resins, surface roughness, AFM, finishing and polishing system

Introducing composite resins in dental practice represented a major step to obtain esthetic restorations. Un important factor that could influence the natural like appearance of composite resin filling is the surface texture [1-5]. The reflected light from the restoration surface is in a direct correlation with the degree of surface roughness [6, 7]. As surface roughness increases, the random light reflection increases and the result is a decrease of composite resin surface gloss [8]. Finishing and polishing procedures have as final objectives obtaining a smooth and glossy surface of composite resins [9, 10]. A lot of factors can affect the texture of the restoration surface: the time of action for every polishing system, the speed of rotating, abrading instruments, the presure applied on the material for filling [11-13]. The type of resin matrix, the size and the amount of mineral filler are also important factors that can influence the surface roughness [14, 15].

Clinicaly is very difficult ot obtain a highly polished surface of composite resins due to the fact that the resin matrix and the fillers do not abrade to the same degree [16]. In this way a lot of irregularities will appear at the composite resin surface. A rough surface of composite restoration allow plaque accumulation, secondary caries formation, gingival inflamation and surface staining [15-18].

Different finishing and polishing techniques have developed during time: multifluted tungsten carbide burs, diamond burs, white stones, rubber points, aluminum oxide pastes, diamond pastes [19, 21]. Their efficiency in obtaining smooth composite surface varies a lot, the hardness, geometry and grit size of the polishing material being of a great importance [22-25].

Experimental part

The composite resins chosen for this study were a hybrid (Valux Plus, 3M ESPE), a microhybrid (Filtek Z 250, 3M ESPE) and a nonohybrid (Herculite XRV Ultra, Kerr), as listed in table 1. A single operator, blinded to the material used, prepared a number of 28 samples having 10 mm in long ,7 mm in width and 2 mm in high of each composite resin by placing the composite resin in contact with plastic matrix strips between two glass slabs in order to flatten the surface. The samples were built-up in one increment of 2mm. Every sample was lightcured for 40 s in one step, using a halogen curing light (Ledent, Ivoclar Vivadent). The mean intensity of the light source was 1000mW/cm^2. The samples of each composite resin were equally split in 4 groups. In control group 7 specimens received no finishing and polishing treatment after being cured under plastic matrix strip. In

* email: stoleriu_simona@yahoo.com

Composite resin	Resin	Filler	Inorganic filler loading	Particle size range
Valux Plus	Bis-GMA TEGDMA	zirconia/silica	66% by volume	0.01μm to 3.5μm
Filtek Z 250	TEGDMA UDMA Bis-EMA	zirconia/silica	60% by volume	0.01μm to 3.5μm average particle size of 0.6μm
Herculite XRV Ultra	Bis-GMA TEGDMA	• prepolymerized filler (barium glass nanoparticles) • nanoparticles (silica) • submicron hybrid filler micron (barium glass)	78 % by weight	• prepolymerized filler 25 μm • nanoparticles 20 – 50 nm • submicron hybrid filler 0,4 μm average particle size of 0.4μm

Table 1
RESIN COMPOSITES USED IN THE STUDY

Composite resin	Mean surface roughness ± SD (nm)*			
	Control group	Finishing and polishing system		
		Diamond bur	Carbide tungsten bur	Diamond one stage polisher
Valux Plus	18.17 (±0.03) Aa	24.64 (±0.06) Ab	21.17 (±0.03) Ac	18.79 (±0.05) Ad
Filtek Z 250	13.52 (±0.07) Ba	20.46 (±0.04) Bb	17.20 (±0.05) Bc	14.14 (±0.07) Bd
Herculite XRV Ultra	14.99 (±0.06) Ca	21.86 (±0.07) Cb	17.75 (±0.06) Cc	15.12 (±0.04) Cd

* Means followed by the same letter are statistically different ($p < 0.05$). Capital letters are for horizontal comparison and small letters for vertical comparison

Table 2
MEAN ROUGHNESS VALUES AND STANDARD DEVIATION OF ALL THREE COMPOSITE RESINS IN CONTROL AND STUDY GROUPS

the first study group 7 samples of each material were finished using fine, safe end taper tungsten carbide bur, having 16 cutting blades (ISO 500314166041) (NTI, Kahla GmbH, Germany) with water cooling, 7 samples were finished using superfine needle diamond bur, having grit particles of 20μm (ISO 806314167504) under continuous water cooling. The polishing speed was 160,000 rotations per minute and the finishing time was 30 s. For 7 samples was used diamond impregnated one stage polisher (ISO 802204) (Germany) with water cooling. The finishing speed was 10,000 rotations per minute and the finishing time was 30 s. After all specimens were finished and polished, they were rinsed with water and for 24 h and air dried. After that the surface of the composite samples was analyzed using atomic force microscopy. The results were expressed as root mean square surface roughness (nm). The results were statistically analysed using ANOVA and post hoc Bonferroni test at a 0.5 significance level.

Results and discussions

Sections of 50, 20, 10, 5, 2 and 1 μm were AFM analyzed for all composite resin samples. A decrease of surface roughness was recorded while the section decreases. The 5 μm sections were chosen for root mean square determination and comparison. AFM aspects of the composite resins 5 μm sections are presented in figure 1.

The mean roughness values and standard deviation of all three systems of finishing and polishing are listed in table 2. The highest value of surface roughness was recorded when finishing Valux Plus using diamond burs, and the lowest value was recorded for Herculite XRV Ultra when polishing with one-step diamond abrasive polisher. Finishing procedure using diamond bur leaded to the highest surface roughness of all composite resins. Surface roughness of Valux Plus was higher than that observed for Filtek Z 250 or Herculite XRV Ultra, irrespective of the system used for finishing and polishing. Significantly differences were obtained in the surface roughness of all three tested composite resins when all finishing and polishing systems were used when comparing to surface roughness from control group. The one-step diamond abrasive polisher leaded to a significant lower surface roughness for all three composite resins when comparing to the surface roughness when tungsten carbide bur or diamond bur were used. The surface roughness of the composite resins that have been studied after finishing using tungsten carbide bur was significantly lower when comparing to diamond bur.

The results of this study showed that surface characteristics of composite resins vary according to the type of finishing and polishing systems. The diamond bur leaded to a significant increase in the surface roughness of all three types of studied composite resins. Other studies

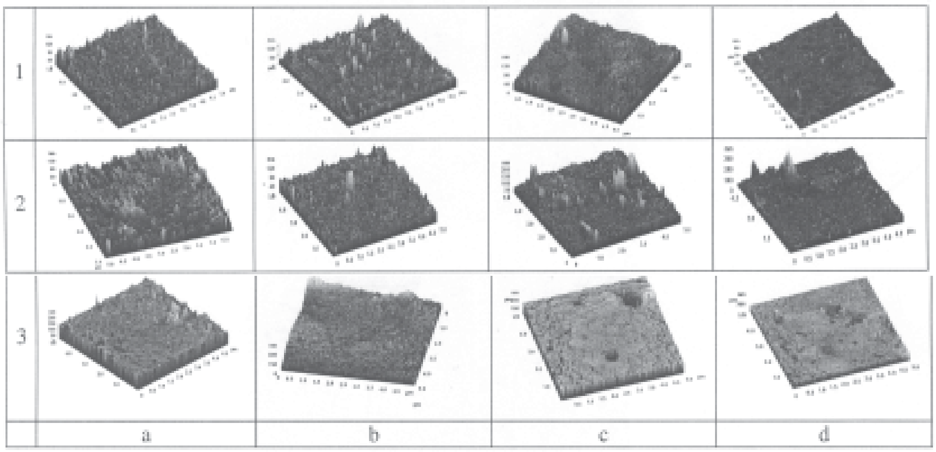

Fig. 1. AFM aspects of the composite resins 5 μm sections: 1. Valux Plus; 2. Filtek Z 250; 3. Herculite XRV Ultra; a. control group; b. finishing using diamond bur; c. finishing using carbide tungsten bur, d. polishing using diamond one stage polisher

also showed that a more irregular surface of composite resins result after finishing using diamond burs [26, 27]. The grain size of diamond burs might be related to surface roughness of composite resins. The scratches that result after using diamond burs may exceed the visible light wavelength and be perceived by the human eye [28]. An important factor in obtaining smooth surface of composite resins is also the pressure applied on the rotating instruments. In this study the diamond burs were not been changed after each use and in this way damages of the uniform wear could appear. Surface roughness is related also with composition and hardness of the particles of the finishing instrument [17]. A composite finishing system is considered to be effective when the abrasive particles are relatively harder than fillers. Otherwise, the polishing agent will remove only the soft resin matrix and leave the filler particles protruding from the surface [29, 30]. Tungsten carbide finishing bur leaded to a significantly lower surface roughness when compared to diamond burs. Due to their lower cutting efficiency, some studies indicated that the carbide bur would be more suitable to smooth and finish, while the diamond burs would be more indicated for gross removal and contouring [31, 32]. In this study the lowest surface roughness of all tested composite resins was obtained when the composite resins were placed in a direct contact with the plastic matrix strips. Previous studies also confirmed these findings [33].

In the present study significant roughness differences were obtained after finishing different composite resins using the same system. The surface roughness could be influenced by the filler size and the filler loading of composite resin [34-36]. It seems that the filler particles situated close one to each other are abble to protect the resin matrix by beeing abraded. In this way decreased size of the fillers could reduce the interparticle spacing. This could be a possible explanation for the lower surface roughness recorded by Herculite XRV Ultra when compared to Filtek Z 250 or Valux Plus.

Conclusions

The surface roughness of composite resins is in relation with the type of composite resin and the type of finishing and polishing system. The one-step diamond abrasive polisher was more efficient in obtaining smooth surface when comparing to tungsten carbide bur or diamond bur. After finishing and polishing, the nanohybrid composite resin had lower surface roughness when comparing to microhybrid and the hybrid composite resin.

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