Surface Characteristics of Restorative Composite Resins after Polishing with Profine Lamineer Tips

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The purpose of this study was to investigate the surface roughness of one restorative composite material when using the Profine System with Lamineers tips. 3 shades of composite resin were used for testing. 15 discs of composite resin were prepared for each shade; 5 discs received no treatment, while the other 10 were divided in two study groups which were polished using either the diamond or the carbide tips using reciprocating movements. The roughness values (Ra; µm) were assessed using a profilometer and the effect of polishing systems on the surface roughness in each group were statistically analyzed. The surfaces of specimens were observed by scanning electron microscopy. The results indicated that the surface roughness depended on type of Lamineer tip and shade of the composite resin.

Keywords: composite resin, reciprocating movements, finishing, polishing, surface roughness

The surface characteristics of the dental restoration influence the esthetic quality, the tactile sensation, the resistance to corrosion-abrasion phenomena and the adhesion of the bacterial biofilm [1, 2]. For composite resins the surface of the restoration is either the result of using Mylar matrices or finishing and polishing procedures when adjustments are necessary. During the last decades, a lot of finishing and polishing systems have been introduced on the market, most of them involving rotary instruments like burs, disks, rubber polishers and brushes used in one-step or multi-step procedures. The abrasives used to impregnate these instruments include diamond, silicon dioxide, silicone carbide and aluminum oxide.

Recently a new system have been introduced for finishing and polishing. Profine PDX system consists of a contra-angle handpiece using reciprocating movement with special finishing and polishing tips - Lamineers LTA (Dentatus AB, Sweden). One of the indications is the removal of restoration overhangs, shaping, finishing and polishing of restorations especially in the subgingival and proximal areas.

The purpose of this study was to investigate the surface roughness of one composite material when using the Profine System with the diamond and carbide Lamineer tips. For evaluation we used a composite material indicated for biomimetic multi-layering technique, as there is a lack of information about the differences of polishability between the enamel shades and dentin shades of these materials [3, 4].

The null hypotheses tested were that would be no difference in surface roughness when using Mylar matrices or polishing with diamond and carbide Lamineer tips for the same composite shade (1) and no difference in surface roughness among the dentin, enamel and universal shades when using the matrix or the same polishing system (2).

Experimental part

One commercially available light-cured composite material was used for testing. Essentia (GC Corporation, Tokyo, Japan) has shades for dentin, enamel and universal purpose, which are based on different formulations. In this study we tested one shade of enamel – Light Enamel (LE), one shade of dentin - Medium Dentin (MD) and the Universal shade (U). The description of the composite materials used in the study according to manufacturer's data is shown in table 1.

A total of 45 composite discs (15 for each shade) were prepared. For each specimen, the restorative material was inserted into a cylindrical silicone mold (4 mm diameter/2 mm thickness), covered with Mylar matrices and pressed with a glass slabs. The specimens were polymerized through the glass slab using a LED light (LEDEX™, WL-070 LED Dental Curing Light Dentmate Technology Co. LTD, Taiwan), for 40 s. For each shade, 5 discs received no treatment, while the other 10 were divided in two study groups which were polished using the Profine system. One group was finished using the diamond tips Lamineers LTA in a multi-step procedure from super-coarse to super-fine size of the diamond particles (red- 150µ, green-100µ, gold-75µ, yellow-50µ, white-30µ, violet-15µ). Each tip was used for 10 s at 7500 rpm. In the tungsten carbide group, the surface of each specimen was finished by using the LTA-39/2 Lamineer tip for 60 s. The prepared specimens were rinsed with water for 10 s and air-dried for 5 s after each session of preparation using the same instrument. All the preparations were performed by the same operator.

The surface roughness was evaluated using a profilometer (Surftest SJ-210, Portable Surface Roughness measuring instrument, Mitutoyo). For each specimen, at least 10 measurements were registered at different locations and in different directions with a cut-of length of

Table 1
COMPOSITE MATERIAL

Shade	Description	Batch Number
Enamel shade LE	Composition including a mix of ultra-fine glass fillers and prepolymerised fillers	1507271
Dentin shade MD	Microhybrid composition	1505111
Universal shade U	Microhybrid composition and additional inorganic fillers comparing to dentin shades	1511131

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0.25 mm, a measuring speed of 0.25 mm/s. The roughness values (Ra; μm) were recorded and the averages were calculated for each material. The effect of polishing systems on the surface roughness in each group was statistically analyzed.

The surfaces of the specimens were observed by scanning electron microscopy using a VEGA II LSH (TESCAN) microscope and photographs of representative areas were taken at 1000X magnification.

Results and discussions

Mean surface roughness values (Ra, μ) and standard deviations are shown in table 2.

The t*est of homogeneity of Variance* according to Levene test have shown that the average roughness are normally distributed for all the groups, therefore for statistical analyze, parametric (ANOVA followed by Bonferroni multiple comparisons) tests have been done to assess the significant differences among the experimental groups.

The first null hypotheses tested was that would be no difference of surface roughness when using Mylar matrices or polishing diamond and carbide Lamineers on the same composite shade. The results of the statistical analyze in terms of comparison between the three types of techniques for each type of material (p values) is shown in table 3. The significance level was considered at $p < 0.05$. The bold letters in each row indicate the significant differences.

The results of ANOVA have shown significant differences between the roughness values of all the groups (Mylar matrix/diamond tips/tungsten carbide tip) ($p > 0.05$). The first null hypotheses was false.

For each composite material, the smoothest surface was created by using Mylar matrix and the differences of surface roughness when comparing with both finishing methods were statistically significant, which is in accordance with previous studies [1-6]. However, in our study the samples surface in direct contact with Mylar strips was not perfect and the average values of surface roughness were higher than those founded by other studies evaluating nanohybrids and microhybride composites, probably because of the imperfections present in the matrix itself [7].

For LE the mean value of roughness when using diamond tips was significantly lower than the mean value when using tungsten carbide tips. This finding is surprisingly as diamond is the hardest abrasive and it is considered to be more appropriate for shaping and not for finishing and polishing since it can produce deeper scratches on the surface of the composite resin, and consequently higher roughness [8]. However, another study reported very good results of the fine diamond powders used for polishing composite resins [9].

On the contrary, for MD and U, the mean surface roughness when using carbide tips was significant lower than the mean value when using diamond tips, which is in accordance with several studies that compared tungsten carbide and diamond finishing instruments used in rotary motion [2, 10].

The second null hypotheses tested was that would be no difference in surface roughness among the dentin, enamel shades and universal shade when using the matrix or the same polishing system. The results of statistical analysis are shown in table 4. The bold letters in each row indicate the significant differences.

For the matrix group the differences have not been statistically significant. These results can be explained as Mylar matrix-created surfaces are less a characteristic of the bulk material and mostly related to the Mylar strip itself [7, 11].

When polishing with tungsten carbide tips, the Ra average values were not significantly different and the lowest value was recorded for the Universal shade. Numerous studies have reported similar results, suggesting that nanohybrid composite resins did not perform better than microhybrid composites in finishing and polishing procedures and smaller filler size did not necessary show lower surface roughness [12-15].

When polishing with diamond tips, MD and U performed similarly in terms of surface smoothness, while the surface of LE was significantly smoother.

The SEM images supported the findings obtained by profilometry. Figure 1 shows the SEM images of the surface morphology achieved with diamond Lamineer tips for Enamel shade (1.a), Dentin shade (1.b) and Universal shade (1.c). Enamel shade was characterized by very fine polishing scratches. Dentin shade and Universal shade show less smooth surfaces.

Figure 2 shows the effect of polishing with carbide Lamineers for Enamel shade (2.a), Dentin shade (2.b) and Universal shade (2.c). All the images reveal relatively smooth surfaces. The surface of the materials showed narrow scratch lines and small irregularities.

Smoothness of the restoration surface is very important for preventing corrosion, staining, plaque accumulation, improving esthetic quality and comfort of the patient [1, 2, 16, 17]. The threshold value for plaque accumulation on the surface of restorative materials is considered to be 0.2 μm in recent studies [12, 18]. Both tactile comfort and

Table 2
MEAN SURFACE ROUGHNESS VALUES AND STANDARD DEVIATIONS IN EACH GROUP

Shade	Finishing/polishing system		
	Matrix (M)	Diamond (DL)	Tungsten Carbide (TL)
Enamel LE	0.05540 ± 0.011673	0.11680 ± 0.012218	0.26260 ± 0.029235
Dentin MD	0.05400 ± 0.010625	0.32610 ±0.036208	0.26870 ±0.034244
Universal U	0.05610 ±0.006315	0.30280 ±0.041731	0.24580 ±0.05600

Table 3
COMPARISON BETWEEN THE THREE TYPES OF TECHNIQUES FOR EACH TYPE OF MATERIAL

p values	Mylar matrix - Diamond tips	Mylar matrix - Tungsten carbide tips	Diamond tips – Tungsten carbide tips
Enamel LE	**0.000**	**0.000**	**0.000**
Dentin DM	**0.000**	**0.000**	**0.001**
Universal U	**0.000**	**0.000**	**0.012**

p values		Dentin MD	Universal U
Mylar matrix	Enamel LE	1.000	1.000
	Dentin MD		1.000
Diamond tips	Enamel LE	**0.000**	**0.000**
	Dentin MD		0.367
Tungsten carbide tips	Enamel LE	1.000	1.000
	Dentin MD		0.683

Table 4
COMPARISON BETWEEN THE COMPOSITE SHADES FOR EACH TYPE OF FINISHING METHOD

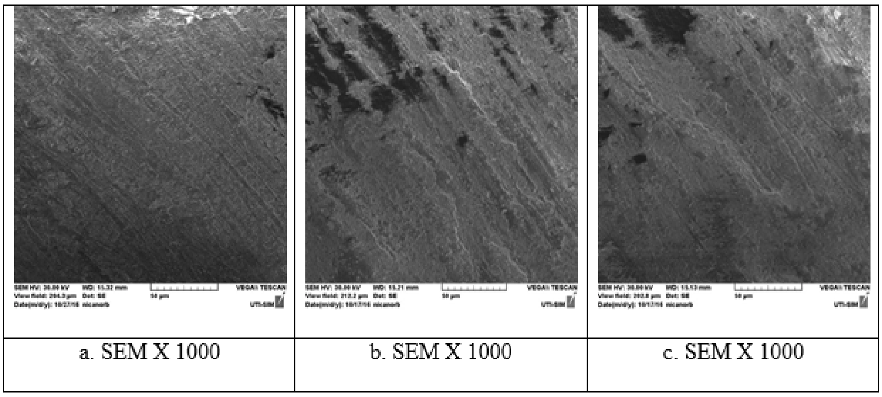

Fig. 1. SEM images of surface morphology for polishing with diamond Lamineers: a – LE; b- MD; c- U

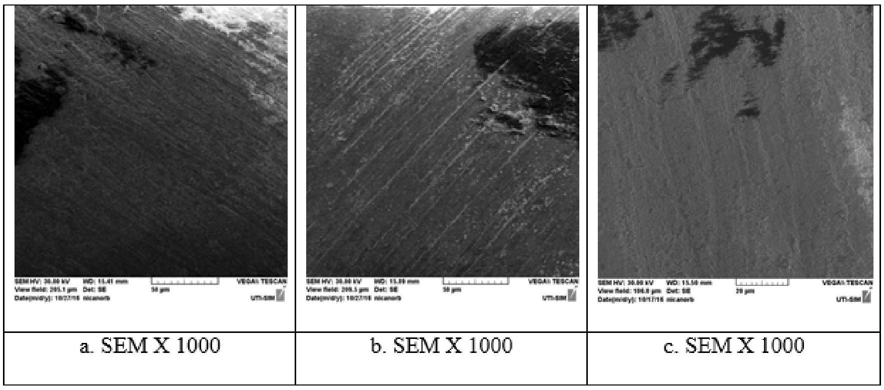

Fig. 2. SEM images of surface morphology for polishing with carbide Lamineers: a – LE; b- MD; c- U

esthetics are acceptable below this value [19, 20]. In our study the average values of surface roughness for all the materials and polishing procedures have been higher than the threshold value of 0.2μ, excepting for Enamel shade finished with diamond Lamineers. This could be a reason for the manufacturer's recommendation to use plastic tips with polishing paste for achieving the final gloss of the surface. However, further studies are necessary to evaluate the surface roughness when using this additional procedure and different types of materials.

In both tested hypothesis, the results related to the enamel shade and diamond Lamineer tips seems to be contradictory. The average value of surface roughness (0.116 μm) is very low for a system designed for finishing and not for polishing restorations. The small dimension of the diamond particles (15 μ) of the super–fine diamond tips could be responsible for these results. Other contributing factors could be the multi-step procedure with gradually decreasing grits and the flexibility of the tip allowing extensive contact in a similar way with polishing systems based on flexible discs, which are considered to be the best polishing instruments in many studies [15, 21, 22].

However, as this high polishability was observed only for Enamel shade, it means that other factors than the characteristics of the abrasives might be responsible. It seems probably that several characteristics of the materials, including the filler size, type and the loading might influence the polishability. According to the manufacturer, the differences are quite significant between the Enamel shades and the Dentin and Universal shades and it was expected that Enamel shade would perform better in terms of polishability as the material has been designed for esthetic restorations. However, this had happened in our study only for the diamond Lamineer tips. Both Dentin and Universal shades are based on a microhybrid composition, the Universal containing additional inorganic fillers. Enamel shades are claimed to feature an innovative composition with a mix of ultra-fine glass fillers and prepolimerized fillers which provide excellent polishability. This formulation suggests a nanofilled or nanohybrid composition [23, 24]. Even though several authors have found minimal differences between microhybrids and nanohybrids reported to the range of filler sizes [14], other factors such as the composition of the particles and the composition and the structure of the matrix (with or without pre-polymerized fillers) might be responsible for the disparity of results even within the same class of materials [5, 24, 25].

For finishing and polishing a composite resin material, the abrasive should be harder than the filler particles in order to remove both resin and filler on the surface, but the grit should be smaller than the particle size of the restorative material that is being polished [26]. As the manufacturer did not provide more information about the composition of the material, we can presume that the extra-fine diamond particles of Laminner tips might have the most adequate hardness and grit to equally abrade the mineral particles, the prepolimerized fillers (with higher toughness than the resin matrix) and the organic matrix of the nanohybrid, producing a more uniform surface comparing to carbide.

Moreover it seems difficult to compare our results with data on rotary polishing systems since the surface qualities depend on the flexibility of the backing material, the hardness of the particles, the geometry of the instruments and the characteristics of the movement [9, 27]. The design of the tips and the reciprocating movement used to activate the instruments are quite different from traditional finishing and polishing systems available on the market.

As both the composition of the restorative material and the polishing system have an influence on the surface roughness, the conclusions of this study does not necessary apply to other composite materials or polishing systems. Under these circumstances, it seems to be quite difficult to choose the perfect match between one specific composite resin and a polishing system when there is such brief information about the material composition and only general recommendation about the finishing and polishing procedure.

Conclusions

The smoothest surfaces were created by using Mylar matrices for all the tested composite shades.

Using reciprocating movement with special diamond and carbide tips seems to be a promising technique for shaping and finishing composite restorations in areas difficult to be reached. However the average values of surface roughness for the tested materials have been higher than threshold value of 0.2 μ, excepting the Enamel shade finished with diamond Lamineer tips. Therefore, additional polishing procedures should be used in order to improve the final gloss of the surface. Further evaluation of the impact of several factors like polishing time and variables related to operator is necessary.

The surface roughness of the tested composite material depended on the composite shade and the type of Lamineer used for finishing procedures. For the enamel shade the surface roughness was lower when using the diamond tips, while for dentin shade and universal shade the surface polishability was higher when carbide tips had been used.

More information about the material composition is necessary in order to choose the most effective instrument for finishing and polishing a specific restorative composite resin.

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Manuscript received: 14.01.2016