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Surface Roughness of Posterior Condensable Composites

SUMMARY

Objective: *The purpose of this study was to evaluate the surface roughness of posterior condensable composites.*

Methods: *Posterior condensable composites, Alert (Jeneric/Pentron) and Surefil (Dentsply), and hybrid composite Z100 (3M), were used in this study. The study material was placed into, and hardened in cavities. After the finishing and polishing procedures were completed, specimens were randomly separated into 3 groups. While the surface roughness values of the first group of specimens were determined with a profilometer, the surfaces of the second group were evaluated using SEM; Vickers micro-hardness measures were applied to the third group of specimens. Data were analyzed using Kruskal-Wallis and Mann-Whitney U tests.*

Results: *All 3 groups were found to be different mutually ($p<0.05$). The surface roughness of condensable posterior composites was greater than that of hybrid composite resins ($p<0.05$). A direct correlation was found between the micro-hardness value and the surface roughness value, indicating that a composite with higher hardness value yielded a higher roughness value ($r=0.738$). SEM images support the statistical evaluation.*

Keywords: Posterior Condensable Composites; Surface Roughness; Micro-hardness

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Introduction

Resin based composite restorations are being used as aesthetic material in restorative dental medicine for the past 30 years. Since they were first manufactured in 1960 by Rafael Bowen, until today they have been constantly improved. The usage of resin based composite materials in posterior teeth as an alternative to amalgam, over the past few years, has presented a number of problems when used in class II and III cavities, such as placement in the cavity[1-3]. These problems have made the development of composites that are more suitable for the posterior teeth necessary[2,4]. Due to their physical and chemical properties, posterior condensable composites have been developed for various cavities in the posterior region. The matrices and organic and inorganic structures composing these composite materials have been changed[5-8]. Another concern in the clinical use of resin-based composite restorative materials is their ability to withstand occlusive forces and stresses of the oral environment, particularly in posterior situations[1,3].

The surface smoothness of restoration material used orally, is important in providing a plaque-free environment and insuring wear resistance[9,10]. Many composites form a rough and dull surface because finishing and polishing procedures are not well done[11-16]. This problem arises from the difference between the micro-hardness of the polymeric matrix and the inorganic components that make up the composite material[12,14,15,17]. Size of the fillers which compose the inorganic component and their dispersion within the matrix are different. Therefore their abilities for polishing are also different[18]. In this study, the surface roughness of posterior condensable composites, which have been produced over the last few years, was evaluated using a profilometer and scanning electron microscope (SEM) and compared with surface roughness of a hybrid composite. In addition to this, in order to understand the relationship between the micro-hardness and surface roughness of posterior condensable composites and hybrid composites, their micro-hardness values were also determined and compared.

Material and Methods

A total of 3 resin-based composites, 2 posterior condensable and 1 hybrid composite, were used in the study. The names, batch numbers and manufacturers of these products are shown in table 1.

Table 1. Composites used in the study

Product	Batch number	Manufacturer
Alert	N15CB	Jeneric Pentron, Wallingford, CT, USA
Surefill	9812000106	Dentsply, Weybridge,Surrey
Z 100		3 M. St. Paul, MN, USA

Acryl blocks with 6 mm wide and 2 mm deep cavities were prepared. The composites were placed into these cavities following the manufacturer's recommendations, a transparent strip band (Du Pont Co, Wilmington, Del) was placed on top and they were pressed down with glass. After the glass plate was removed, they were irradiated for 40 seconds under visible light (Cavex clearlicht HL 500, Cavex Holland BL). The specimens were then immersed in distilled water for 1 week and incubated at 37°C. At the end of this period, finishing and polishing procedures were completed for all of the specimens. As surfaces of all the specimens would be appropriate for clinical settings, they were processed under water with a flame-shaped diamond mill without applying pressure. This procedure took 15 seconds.

One type of polishing system was used in this study. (Hawe Neos Dental, Dr. HV Weisserfluh Ltd, Switzerland)[19]. In this system, coarse (white), medium (blue), fine (yellow), and X-fine (pink) polishing disks were applied under water (according to the manufacturer's recommendation), starting from course to fine, for 15 seconds each, with a 30000 rpm rotating tool. After each successive change in abrasive, the specimens were rinsed thoroughly to remove all debris from the previous abrasive. Then white rubber was applied for 15 seconds, and the last step of the polishing procedure was completed using a rubber cup (Crescent Dental Mfg Co, Lyons III) and luster paste (Sybron/Kerr, Romulus, Mic.).

During the polishing of each specimen, care was taken to apply the same amount of pressure in the same direction. All finishing and polishing procedures were done by the same investigator on the same day to reduce variability.

From each group of study material for which the finishing and polishing procedures were completed, 15 specimens were randomly picked for the surface roughness measurements and SEM analysis, and 10 specimens were randomly picked for micro-hardness measurements.

Surface Roughness Measurement

Surface roughness (Ra-value or arithmetic average roughness) was determined using a Mahr Concept perthometer tool (Perthen Mahri Germany) with a 0.2µm tip radius and wave length ± 250 that can take measurements within a 3.00 mm^2 area. The average was taken of 5 Ra-values taken from each specimen.

SEM Analysis

Specimens with the finishing and polishing procedures completed were prepared to be examined under SEM (Joel JSM 5200, Tokyo, Japan). Specimens were plated with 200 A^o gold. Scanning Electron Micrographs made at original magnifications of x100 and x500 were evaluated and compared for surface texture and roughness. The samples were tilted and examined at a 10° angle.

Surface Micro-hardness Measurement

10 samples randomly selected from each study material with the finishing and polishing procedures completed were used to perform micro-hardness measurements. The vickers M41 Photoplan Microscope with micro-hardness attachment (Vickers Instruments, York, UK), which is a pneumatically loaded micro-hardness tester, was used to measure the surface hardness. This test involves applying a 136° diamond pyramid shaped indenter into the surface of the material being tested, and measuring the diagonals of the indentation produced. 10 readings were taken at different locations on the surface of the specimen. The lengths of the diagonals of the indentation were measured and then averaged. Using this value, VHN was obtained from 100 g Vickers Hardness Scale. This procedure was repeated for all specimens.

The results obtained by using the above tests for the ability of polishing of the 3 types of resin based composite restorations used were statistically evaluated by Kruskal-Wallis and Mann-Whitney tests. The presence of a correlation between the surface roughness and micro-hardness values was also evaluated.

Results

The surface roughness values (Ra-values), arithmetic means, standard deviation and median values of the resin based composite materials used in this study are as shown in table 2. According to the Kruskal-Wallis test, the difference between all the study groups in respect to surface roughness values was found to be significant ($p< 0.05$).

When the surface roughness values were analyzed according to the Mann-Whitney test, 3 different resin-based composite resins were found to be different from each other. The obtained results are as summarized in table 3.

Table 2. Surface roughness (Ra-value) in µm of composites used in this study

Product	Mean	SD	Median
Alert	0.3150	5.720E-02	0.2950
Surefill	0.2010	2.283E-02	0.1950
Z 100	0.1720	1.229E-02	0.1700

Table 3. Composites compared in respect to their surface roughness (Mann-Whitney test)

	Alert	Surefill	Z 100
Alert	-	0.000*	0.000*
Surefill	-	-	0.000*
Z 100	-	-	-

* - significant ($p<0.05$)

The surface profile tracings obtained from resin based composites are as shown in figure 1. The SEM analysis was generally coherent with the profilometric data. Particles broke off from the surface of the first group of posterior condensable composites had the highest surface roughness values. The surface compactness of this group could be observed under x500 magnification. Stick and spherical particles were observed to be exposed from the surface (Fig. 2). In the second group of posterior condensable composites parallel to the surface roughness data, a more homogeneous surface can be observed with rarely a few particles sticking out of place. There are scratches and striations on the surface (Fig. 3). The smoothest surface among all study groups was observed in the hybrid composites, which make up the third group. Composite filler structure was observed. In addition to this, the surface was well polishable (Fig. 4).

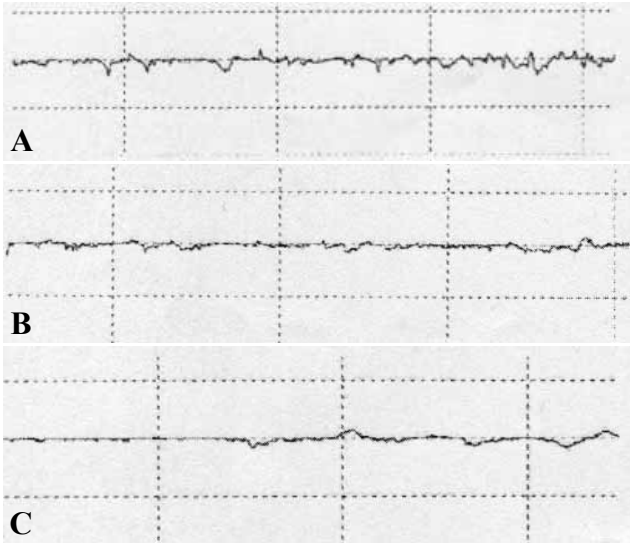

Figure 1. Surface profile tracing of composites finished and polished (A - Alert; B - Surefill; C - Z 100)

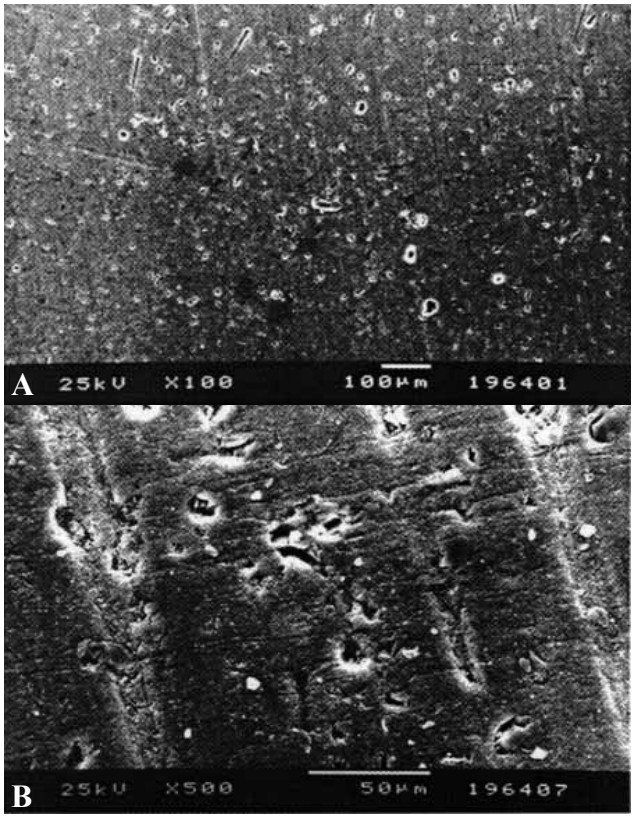

Figure 2. Scanning electron micrographs depicting surface profiles of Alert (magnification: A - x100; B - x500)

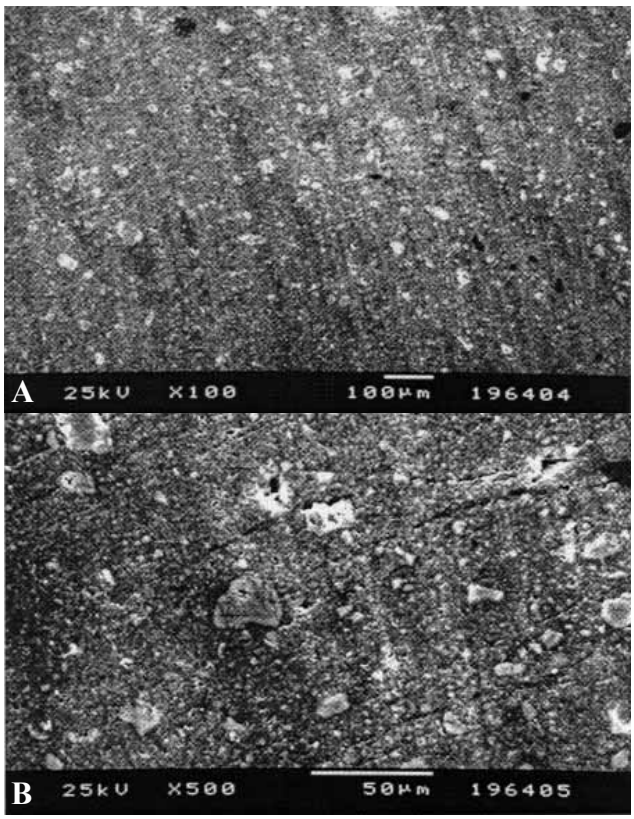

Figure 3. Scanning electron micrographs depicting surface profiles of Surefill (magnification: A – x100; B - x500)

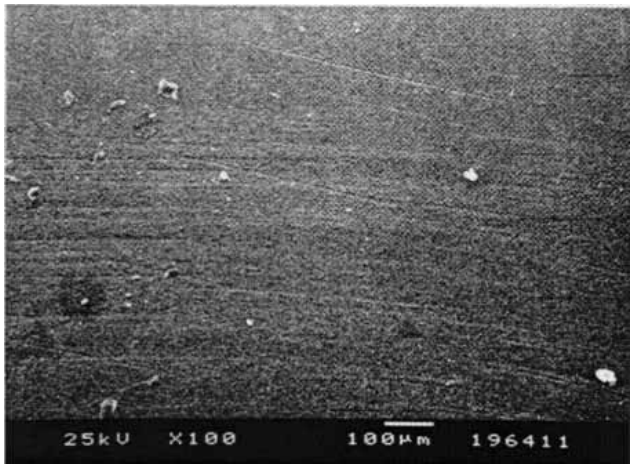

Figure 4. Scanning electron micrograph depicting surface profiles of Z 100 (magnification x100)

Micro-hardness values are as shown in table 4. The difference between all 3 groups in respect to micro-hardness was significant according to the Kruskal Wallis test ($p<0.05$). The results obtained when study materials were compared according to the Mann-Whitney test in respect to their micro-hardness values are shown in table 5.

Table 4. Micro-hardness (VHN) of composites used in this study

Product	Mean	SD	Median
Alert	127.24	37.62	114.42
Surefill	87.34	17.47	82.70
Z 100	68.16	10.74	65.35

Table 5. Composites compared in respect to their micro-hardness (Mann-Whitney test)

	Alert	Surefill	Z 100
Alert	-	0.004*	0.000*
Surefill	-	-	0.005*
Z 100	-	-	-

* - significant ($p<0.05$)

When the presence of a correlation between micro-hardness and surface roughness of resin based composites used in the study was evaluated, roughness was observed to increase as micro-hardness increases in all of the groups; correlation coefficient was found to be r=0.73 with p=0.000 (Fig. 5).

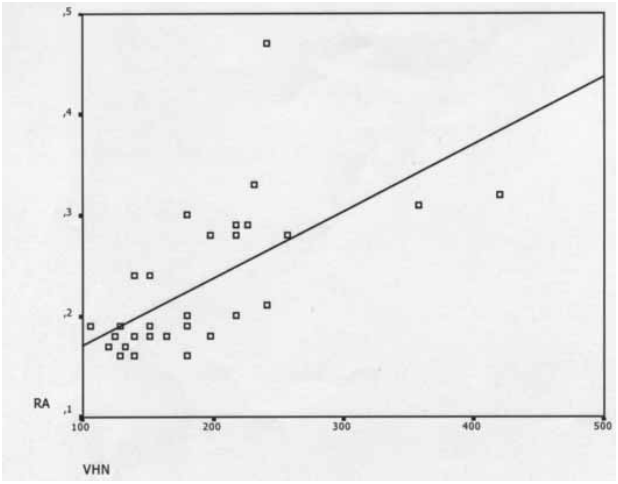

Figure 5. Correlation graph depicts hardness value and surface roughness value

Discussion

Among the 3 different resin-based composite materials, finished and polished in the same manner and conditions, the condensable posterior composites in which the filler structure and proportions were changed for usage in posterior situations were found to have, unlike hybrid composites, a rougher surface. The SEM images of the specimens are supported by profilometric measurements. The roughness values were in this order: Alert; Surefil; Z 100. In fact, the particles of Alert and Surefil condensable posterior composites have broken off from the surface during the finishing and polishing procedures structure (Figs. 2 and 3). The scratches formed during the finishing procedure have not been eliminated by the polishing procedure. On the other hand, with the hybrid composite, to which the same finishing and polishing procedures were applied, a reasonably smooth surface was obtained during the polishing procedure (Fig. 4). Although the condensable posterior composites were found to have a different surface roughness than the hybrid composite, the two condensable posterior composites used in the study were also different from each other. Alert, which has sticks, 60-80 µm long and 6 µm in diameter and particles of various cross sections in its structure, had a rougher surface than Surefil that has particles of various cross sections and sizes in its structure. The Vickers micro-hardness measurements, profilometric measurements and SEM images of the specimens, were on the same line. The composite material with the highest surface roughness value, that does not have a homogenous surface observed in the SEM images, also had the highest VFN values.

Studies have been conducted on physical properties of condensable posterior composites developed over the past few years for use in class II and III cavities, as a form of composite material used as an alternative to amalgam in posterior teeth. In these studies physical properties in question are reported to be no better than those of hybrid composites. In addition to this, it is reported that filler proportion has been increased to increase viscosity in

these composites, and this is reported to cause an increase in porosity[5-7]. In condensable posterior composites the particle surfaces are made rough to make placement in cavity easier. This causes an increase in surface roughness[4-7,20]. As the 2 types of condensable posterior composites used in this study have higher micro-harness values than the conventional hybrid composite, their surface roughness values are also greater. The American Dental Association (ADA) Council Dental Materials considered composites containing filler particles size up to 5 μm as "polishable" composites[10,21]. Sizes of the condensable composites used in this study were much bigger and this clearly exposes the problem in their ability for polishing.

Conclusions

Posterior condensable composites with large filler particles produce a significantly higher surface roughness values than those with small filler particles. Statistical correlation was observed between the micro-hardness value (VHN) and surface roughness value. Composites with a higher micro-hardness value produce a correspondingly higher roughness value (r).

SEM study indicated that there are scratches and exposed filler particles on the surface of posterior condensable composites, whereas the surface of the hybrid composite is fairly smooth and homogeneous. In order to benefit from the obtained properties of condensable posterior composites and to correct their surface roughness, a layer which has better polishable properties should be formed on the surfaces of these restorations.

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