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Comparative Evaluation of surface roughness of Micro hybrid and Nanohybrid composites using four different polishing systems - An Invitro study

[1]Dr Neelima Narayanan, Post Graduate Student, Department Of Conservative Dentistry And Endodontics, Mahe Institute of Dental Sciences And Hospital, Chalakkara, Mahe(U.T of Puducherry), India

[2]Dr George Thomas, MDS, Professor & Head, Department of Conservative Dentistry And Endodontics, Mahe Institute of Dental Sciences And Hospital, Chalakkara, Mahe(U.T of Puducherry), India

[3]Dr Sunil Jose, MDS, Professor, Department of Conservative Dentistry And Endodontics, Mahe Institute of Dental Sciences And Hospital, Chalakkara, Mahe (U.T of Puducherry), India

[4]Dr Sona Joseph, MDS, Reader, Department of Conservative Dentistry And Endodontics, Mahe Institute of Dental Sciences And Hospital, Chalakkara, Mahe (U.T Of Puducherry), India

[5]Dr Sai Charan G, MDS, Senior Lecturer , Department of Conservative Dentistry And Endodontics, Mahe Institute of Dental Sciences And Hospital, Chalakkara, Mahe(U.T of Puducherry), India

Corresponding Author: Dr George Thomas, MDS, Professor & Head, Department of Conservative Dentistry And Endodontics, Mahe Institute of Dental Sciences And Hospital, Chalakkara, Mahe(U.T of Puducherry), India

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Abstract

Introduction: Resin-based restorative materials have replaced traditional restorations in modern dentistry. Composites are the materials of choice owing to their esthetics and adhesive properties. Long term reliability of composite restorations was uncertain until recently. But advancements in material science have negated those concerns. One of the factors that determine the long-term reliability of composites is the quality of surface finish. Hence it is appropriate that the surface of these restorations are highly finished and polished for their long-term success in the oral cavity. The most common methods employed for finishing and polishing composite restorations are by using rotary abrasive discs and strips. This study aims to compare the efficacy of some of the commercially available polishing systems on micro hybrid and nanohybrid composites.

Aim: To evaluate and compare the influence of different polishing systems on the surface roughness of micro hybrid and nanohybrid composite resins.

Materials and methods: A total of fifty-six sample composite discs were prepared. Ivoclar Te Econom Plus micro hybrid and 3M Filtek Z250 nanohybrid composites were used to make samples in tablet moulds. Shofu composite polishing system, Diacomp polishing system, Super snap polishing system, and Sof Lex XT disc polishing systems were used in this study. Composite discs were polished according to manufacturers' instructions. The initial surface roughness before polishing and final surface roughness after polishing were measured using a digital roughness meter. The data were statistically analyzed using paired and unpaired t-tests.

Results: Among the groups, micro hybrid composites exhibited a maximum surface roughness value before and after polishing. After polishing, each of the polishing systems was able to reduce the surface roughness below the required threshold value of 200 nm. Among nanohybrid composites, the Super snap polishing system gave a minimum surface roughness value. The results showed that there is a huge difference in surface roughness after polishing with four different polishing systems, based on p-value readings (<0.05).

Conclusion: Significant differences are noted in surface roughness before and after using polishing systems. Nano-hybrid composites polished with Super snap showed the least surface roughness among the groups compared.

Keywords: Micro hybrid composite, nano-hybrid composite, digital roughness meter, polishing systems

Introduction

The advent of resin-based restorative materials has changed the practice of dentistry forever. The pioneering work done by Dr. Ray Bowen and Michael Buonocore and later by Nakabayashi paved the way for understanding the science of adhesive dentistry[1]. Today composite restorations have virtually replaced all traditional restorative materials such as amalgam. The success rate or longevity of the composite restoration is a foregone conclusion today. A highly finished and polished composite restoration can survive as an ideal posterior restorative for many years. The strength of composite restorative is determined by the type and quantity of filler loading. But high filler loading can have certain deleterious effects on the surface roughness and polish ability of composite.

The surface texture characterization of composites enhances the esthetics, stability, and longevity of restored teeth. The common practice to improve the surface characteristics is finishing and polishing the composite. Along with composite resin, finishing and polishing systems also evolved in recent years. This improvement in both resin and polishing systems has reduced staining, plaque retention, recurrent caries, gingival irritation, etc. to large extent.

The advancement in the polishing system includes improvement in abrasive systems like aluminum oxide, carbide compounds, diamond abrasives, silicon dioxide, zirconium oxide, etc. Both qualitative methods such as scanning electron microscopy and quantitative method profilometry can be used to measure surface roughness. There are advancements in methods for the measurement of surface roughness also. There is a difference in the interaction of different composite resin with different polishing systems also. Hence the purpose of this in vitro study is to evaluate and compare the surface roughness of micro hybrid composite (Te Econom Plus) and nanohybrid composite (Filtek Z250) after finishing and polishing with four contemporary finishing and polishing systems (Shofu, Diacomp, Super snap, and Sof lex XT discs)

Materials and Methods

56 disc-shaped composite samples of both Te-Econom Plus micro hybrid and 3M Filtek Z250 nanohybrid composite resin were prepared (Fig 1). Samples were marked using airotor bur on the non-testing surfaces. Composites were packed in tablet moulds (size-10*5*10) and light-cured it for 40 seconds (Fig 2). Specimens were then cleaned in 70% ethanol in an ultrasonic bath for 2 minutes, rinsed, and dried. Samples were sandblasted and polished with medium grit Sof Lex XT discs to ensure uniformity. Specimens were rinsed with combined air and water spray and air-dried to remove excess moisture. To further remove surface debris, impressions using a low-viscosity polyvinyl siloxane were taken and allowed to set for 5 minutes. These impressions were discarded. Initial surface roughness was measured using a digital surface roughness meter. Samples were divided into 4 groups and polished accordingly using 4 different polishing systems - Shofu, Diacomp, super snap, and Sof Lex XT discs. Final surface roughness was measured using the same digital roughness meter. For testing surface roughness, each composite disk was placed on the platform of the digital roughness meter, and the nib was placed in the correct position for making a trace of 3 mm, and Ra values were taken.

Group a: 14 random samples polished using SHOFU polishing system

Group b: 14 random samples polished using DIACOMP polishing system

Group c: 14 random samples polished using SUPER SNAP polishing system

Group d: 14 random samples polished using SOF LEX XT DISC polishing system

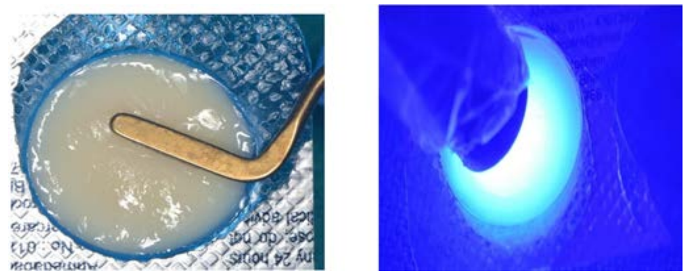


Fig 1: preparation of composite disks

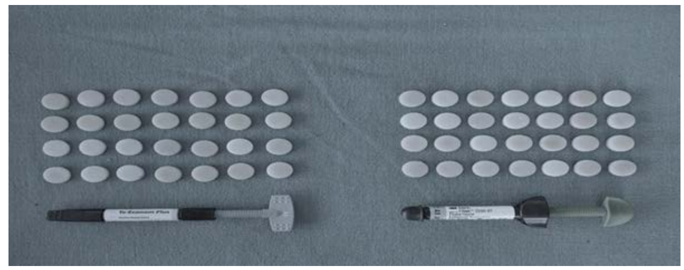


Fig 2: disk-shaped composite samples

Statistical Analysis: The results were assessed using paired and unpaired t tests.

Results

Group A: (Micro hybrid and nanohybrid composite resin polished using Shofu polishing system)

Difference in surface roughness before and after polishing has been noted. Micro hybrid composite exhibited a maximum surface roughness value of 1294.29±65.25 before polishing when compared to nanohybrid composite with an initial surface roughness value of 1053.14±115.78. After polishing with the Shofu polishing system, there is a significant difference in roughness value for both composites. The value is below the desired threshold value of 200 nm (138.14±10.37 for micro hybrid and 123.14±6.99 for nanohybrid composite resin).

Group B: (Micro hybrid and nanohybrid composite resin polished using Diacomp polishing system)

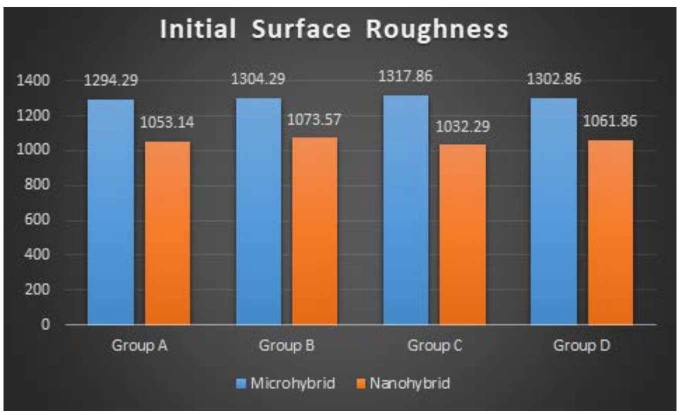
After polishing with the Diacomp polishing system, there is a difference in roughness value for both composites. The values are 178.43±7.07 for micro hybrid and 168.43±7.89 for nanohybrid composite resin.

Group C: (Micro hybrid and nanohybrid composite resin polished using super snap polishing system)

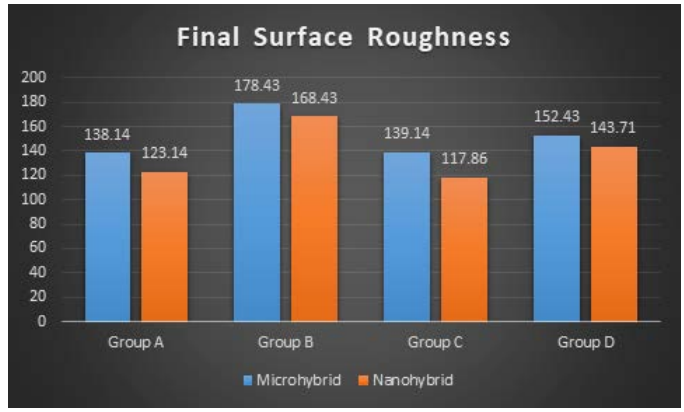
The Super snap polishing system exhibited the lowest value of surface roughness for both micro hybrid and nanohybrid composite resin. The values are 139.14±8.63 for micro hybrid and 117.86±8.65 for nanohybrid.

Group D: (Micro hybrid and nanohybrid composite resin polished using Sof Lex XT disc polishing system)

After polishing the values obtained are below the threshold. The values for micro hybrid and nanohybrid composite resins are 152.43±5.38 and 143.71±7.85 respectively.



Graph 1: Initial surface roughness of micro hybrid and nanohybrid composite resins



Graph 2: Final surface roughness of micro hybrid and nanohybrid composite resins

Table 1: Intragroup comparisons of surface roughness using paired t-test in micro hybrid resins before and after polishing

Polishing Systems	Mean Difference	SD	SE	95% CI		t-value	Df	p value
				Lower	Upper			
Group A	1156.14	61.179	23.123	1099.562	1212.724	49.999	6	0.000*
Group B	1125.86	68.101	25.740	1062.874	1188.840	43.740	6	0.000*
Group C	1178.71	58.656	22.170	1124.466	1232.962	53.167	6	0.000*
Group D	1150.4	60.882	23.011	1094.122	1206.735	49.994	6	0.000*
*<0.05- statistically significant, SD- standard deviation, SE-standard error, CI- Confidence Interval								

Table 2: Intragroup comparisons of surface roughness using paired t-test in nanohybrid resins before and after polishing

Polishing Systems	Mean Difference	SD	SE	95% CI		t-value	Df	p value
				Lower	Upper			
Group A	930.000	114.34	43.217	824.253	1035.747	21.520	6	0.000*
Group B	905.143	102.33	38.677	810.503	999.783	23.402	6	0.000*

Group C	914.429	82.80	31.296	837.851	991.006	29.219	6	0.000*
Group D	918.143	93.50	35.338	831.674	1004.612	25.982	6	0.000*
*<0.05- statistically significant, SD- standard deviation, SE-standard error, CI- Confidence Interval								

Table 3: Comparison of initial surface roughness of different polishing systems in micro hybrid and nanohybrid composites using unpaired t-test

Polishing Systems	Mean Difference	SE of difference	95% CI		t-value	p value
			Lower	Upper		
Group A	241.15	50.23	128.35	353.93	4.80	.000*
Group B	230.71	47.54	124.21	337.21	4.85	.001*
Group C	285.57	35.69	206.37	364.77	8.0	.000*
Group D	241	41.93	148.40	333.60	5.75	.000*
*<0.05- statistically significant, SD- standard deviation, SE-standard error, CI- Confidence Interval						

Table 4: Comparison of final surface roughness of different polishing systems in micro hybrid and nanohybrid composites using unpaired t-test

Polishing Systems	Mean Difference	SE of difference	95% CI		t-value	p value
			Lower	Upper		
Group A	15	4.725	4.542	25.458	3.175	.009*
Group B	10	4.004	1.264	18.736	2.497	.028*
Group C	21.29	4.618	11.224	31.348	4.609	.001*
Group D	8.7	3.596	0.765	16.664	2.423	.035*
*<0.05- statistically significant, SD- standard deviation, SE-standard error, CI- Confidence Interval						

Table 5: Association of surface roughness difference with micro hybrid and nanohybrid composites using unpaired t-test

Polishing Systems	Mean Difference	SE of difference	95% CI		t-value	p value
			Lower	Upper		
Group A	226.14	49.01	115.59	336.70	4.61	.001*
Group B	220.71	46.46	117.79	323.64	4.75	.000*
Group C	264.29	38.35	179.69	348.88	6.89	.000*
Group D	232.29	42.17	138.71	325.86	5.51	.000*
*<0.05- statistically significant, SD- standard deviation, SE-standard error, CI- Confidence Interval						

Interpretation

There was a significant difference in initial mean roughness values between micro hybrid and nanohybrid composites before using polishing systems. Each value is above the threshold value of 200 nm. After polishing with different polishing systems there is a marked reduction in surface roughness and the value is below the desired threshold value. Nanohybrid composites have lower surface roughness when compared to, micro hybrid composites before and after polishing. The final surface roughness value is lowest (117.86±8.65) when the nanohybrid composite is polished with a Super snap polishing system. This is followed by the Shofu composite polishing system (123.14±6.99), Sof Lex XT disc (143.71±7.85), and Diacomp polishing system (168.43±7.89). In the case of micro hybrid composite the final surface roughness value is lowest when polished with the Shofu polishing system (138.14±10.37). This is followed by the Super snap composite polishing system (139.14±8.63), Sof Lex XT disc (152.43±5.38), and Diacomp polishing system (178.43±7.07). All the values are statistically significant (p value<0.05) with surface roughness more for micro hybrid composite.

Discussion

The use of composite restorative materials has seen an exponential increase in modern times because of patient demand for esthetic restorations. Also, the availability of composite resins with high strength and excellent esthetics has contributed to this increase. The composite materials are available as flowable and packable types based on their consistency. They are also available as bulk-fill and conventional based on their curing. Based on their particle size they are available as conventional, micro hybrid, and nanohybrid composite materials.[2] The surface quality is also influenced by many factors related to the composite resin. The factors are the filler particle characteristics, resin matrix content, filler load, silane coupling agent, and also the degree of conversion after light curing.[3] Differences in the hardness of filler particles influence the polish ability of the composite resins. If there is an insufficient abrasiveness of the polisher particles when compared with the composite resin fillers, this will abrade the matrix and leave the filler particles in protrusion. Also, insufficiently bonded fillers may debond and dislodge thus leaving a dull surface. Thus the combination of composite resin and polisher influences the result, with some polishers leaving an excellent finish on some composite resins but a less optimal finish on others[11].

A positive correlation was found between surface roughness and the amount of plaque accumulation. The factors that mediate plaque accumulation are 1) surface roughness; 2) marginal fit and 3) contour. Polishing of the composite materials ensures the oral health and longevity of restorations. A smooth surface reduces the likelihood of adhesion, which means plaque is less likely to accumulate on a polished surface.

The type of composite material and the finishing and polishing systems play an important role in bringing adequate smoother surfaces. It is well known that smaller particles reduce the surface roughness after polishing procedures.[3] Traditionally, ideal polishing protocols have been explained as a selective wear process using a sequence of abrasive particles from coarse grit gradually decreasing toward fine grit[10,11]. Currently, a variety of polishing systems are commercially available. Some systems require multiple steps, whereas others are simplified and require only one grit used with gradually decreasing pressure. The hardness of the backing or rubber media into which the abrasive particles are embedded influences the surface quality.[11]

The best surface quality with the lowest surface roughness has often been obtained with a composite resin cured against a Mylar strip.[4,5,6] However, this surface has a resin-rich layer and presents a lower hardness. To prevent wear and discoloration, it is suggested to finish and polish this surface.[7]

This study evaluated the effect of different commercially available polishing systems on the surface roughness of composite resins. The results of the present study suggest that a single polishing system does not produce the same surface quality for all composite resins. This may not be entirely attributed to the quality of the polishers but also the interaction between the polisher and the composite resin. This is following the findings of previous studies[8,9]. And this study concludes that the Super snap polishing system produces a lower surface roughness for nanohybrid composites when compared to other polishing systems. This finding is in accordance with the study conducted by Pierrie et al[11]. Shofu polishing system produces the lower surface roughness for micro hybrid composites and the Super Snap polishing system also gave comparable results. This may be due to the influence of the hardness of the backing or rubber media into which the abrasive particles. The hardness of the abrasive particles varies and may be classified as follows according to Mohs's hardness scale: diamond> silicon carbide> tungsten carbide> aluminum oxide> zirconium silicate. This is in accordance with Jefferies et al[9]. Several factors have been proposed to affect the polish ability of composite resin, including the polishing system, the composite resin used, and variables associated with the operator.

In this study, we have evaluated the initial surface roughness of micro hybrid and nanohybrid composite using a digital surface roughness meter. The results were tabulated. The result correlates with various previous studies suggesting micro hybrid composites have more surface roughness and hence less polish ability than nanohybrid composite[12,13]. All the samples were again tested after polishing with four different polishing systems. The four groups were evaluated using the same digital surface roughness meter. A decrease in surface roughness values was observed in all the 4 subgroups i.e. Shofu composite polishing system, Diacomp, super snap, and Sof Lex XT disc compared to the surface roughness before polishing. [12,13,14]

Among the polished groups, the smoother surfaces were seen in the Super snap group compared to other samples($P\text{-value} < 0.05$)[11]. Each polishing system could reduce the surface roughness below the desired threshold value of 200 nm.[12,13,14]

Conclusion

Within the limitations of the study, it can be concluded that polishing systems and their appropriate use plays a major role in improving the longevity of restorations. The polishing system and the composite resin influence the surface roughness. Also, interaction is noted between the resin and polishing system.

The result of the present study suggests that the super snap polishing system reduced the surface roughness to the lowest value for nanohybrid composite and the Shofu polishing kit reduces the surface roughness to the lowest for micro hybrid composite resins. All the polishing systems used in this study were able to reduce the surface roughness below the desired threshold value.

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