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Comparison of surface roughness of nanofilled and nanohybrid composite resins after polishing with a multi-step technique

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Abstract. To compare the surface roughness of nanofilled and nanohybrid composite resins after polishing using a multi-step technique. 40 composite resin specimens were divided into two groups (20 nanofilled specimens using Filtek Z350 XT [group A] and 20 nanohybrid specimens using Filtek Z250 XT [group B]), prepared, and then polished. After immersion in artificial saliva for 24 hours, the surface roughness was measured with a surface roughness tester. The mean surface roughness results along with the standard deviation of group A were 0.0967 µm ± 0.0174, while the results of group B were 0.1217 µm ± 0.0244. Statistically (with $p = 0.05$), there were significant differences between each group. The surface roughness of a nanofilled composite resin after polishing with a multi-step technique is better than that of a nanohybrid composite resin.

1. Introduction

Nanohybrid and nanofilled resins were discovered along with the development of nanotechnology in the field of conservation dentistry, specifically in restoration [1]. Nanohybird composite resin contains a combination of micro and nano sized filler with a diameter of 0.3–1 µm and 0.02–0.05 µm, respectively [2]. Additionally, nanofilled composite resin has nano particles as filler that are both single (nanomer) and cluster (a group of nano particles called a nanocluster). The size of nano particles varies from 5–75 nm [3].

A composite resin surface produced a high surface roughness level after polymerization. Roughness is mainly influenced by the composite resin filler. The larger the size and load of filler particle in a resin product, the rougher the surface [4]. Surface roughness can cause problems such as an increased retention of plaque and microorganisms, which can further develop into secondary caries and restoration failure. Surface roughness can also cause food particles to easily adhere to the restoration, causing increased discoloration. Additionally, surface roughness can wear out the opposite tooth enamel, and reduce patient comfort and satisfaction (a 0.3 µm change in surface roughness can be felt by a patient's tongue). A study showed that bacteria could adhere easily to a composite resin surface with a roughness level of 0.2 µm or more. Furthermore, a rough composite resin surface could produce a dull, unnatural clinical appearance [5].

In order to resolve this problem, referring to standard operating procedure, finishing and polishing should be done after every treatment using a composite resin. Polishing is done to produce good physical properties with a smooth and shiny surface so that an esthetic restoration of good quality can be achieved

[6]. The effectivity of polishing is affected by a few factors, one of which is the materials used for polishing [7].

There are two methods of polishing: a single-step and a multi-step technique. Diamond materials are usually used for a single-step technique and only need one step of polishing, while a multi-step technique uses materials (usually aluminum oxide) gradually decreasing from the most abrasive to the smoothest [8]. According to Nair *et al*., in their study of nanofilled resin, the use of a multi-step technique proved to be more effective and produced a smoother surface [9]. This was possible because a multi-step technique uses more than one material from the most abrasive to the smoothest, therefore eliminating matrix and filler particles and simultaneously resulting in lower surface roughness. Watanabe also concluded that a multi-step polishing technique would produce a smoother surface than a single-step technique which used diamond particles [10].

Meanwhile, studies like Da Costa's proved that nanofilled composite resin surface roughness was better than nanohybrid resin after polishing [11]. On the contrary, other studies have proved that nanohybrid surface roughness after polishing was better than that of nanofilled resin [12]. There was a notable difference in results from those few studies. Therefore, we investigated the comparison of nanofilled and nanohybrid composite resin surface roughness after polishing using a multi-step technique. This study was conducted to provide clinicians with a better understanding of the best composite resin restoration for daily practice, especially considering esthetics and strength of composite resin inside the oral cavity.

2. Materials and Methods

Molds were made in cylindrical metal with a diameter of 6 mm and a height of 3 mm. Nanofilled and nanohybrid type composite resins (Filtek Z350 XT shade A3 Body, Filtek Z250 XT shade A3, 3M ESPE, USA) were prepared. Nanofilled and nanohybrid composite resins were then poured into the molds. A LED light cure unit (HILUX, Benlioglu, Europe) was used to light-cure the composite resin for 20 seconds in a 2 mm distance from the specimens' surfaces. The finishing procedure was done using the coarse type *Sof-Lex™ Extra Thin Contouring and Polishing System (3M ESPE, USA)* for 20 seconds.

Specimens were fixated to a glass slide using plasticine in a horizontal plane. Specimens were positioned according to the instrument with the stylus placed on the edge. Initial roughness measurements were recorded using a surface roughness tester on three different points with a 0.2 mm/sec cut-off value and a 0.25 mm/sec stylus speed.

Specimens were polished using a multi-step technique in dry conditions with medium, fine, and superfine grit sizes from the *Sof-Lex™ Extra Thin Contouring and Polishing System (3M ESPE, USA*). Each size was used for 20 seconds under light pressure in a one way motion. Debris was removed using air spray for five seconds after every polishing procedure. Specimens were then immersed in artificial saliva and stored in 37^{o}C for 24 hours.

Surface roughness was measured using a Surface Roughness Tester (Mitutoyo SJ 301, Japan). The same procedure was used for the measurements before and after the finishing procedure. The scanning electron microscope (SEM) photographs were taken from one random specimen from each group.

Data were analyzed statistically using SPSS software. The surface roughness means of each group after polishing were tested using the independent t-test with 5% significance if the data were normally distributed and homogeneous. Results were significantly different with $p \leq 0.05$.

3. Results and Discussion

3.1 Results

Measurements were done after the finishing and polishing procedures. Statistical analysis was only used on the measurement data after the polishing procedure. The surface roughness measurements between each group after the polishing procedure can be seen in Figure 1 & 2. Group A (nanofilled) showed a higher surface roughness compared to group B (nanohybrid).

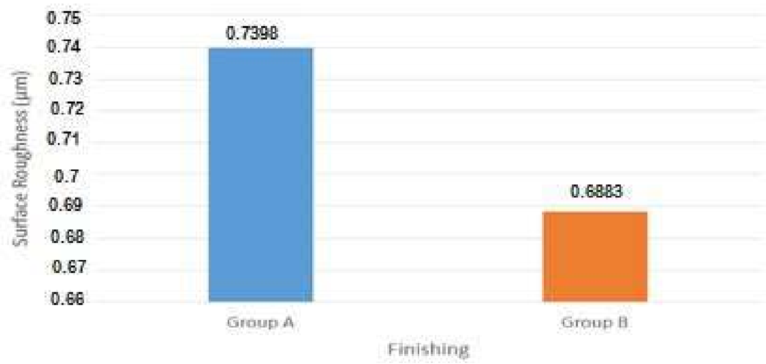


Figure 1. Surface roughness comparison between groups before the polishing procedure. Group A: Nanofilled composite resin Filtek Z350 XT, Group B: Nanohybrid composite resin Filtek Z250 XT, Finishing procedure using coarse type Sof-Lex XT Disc

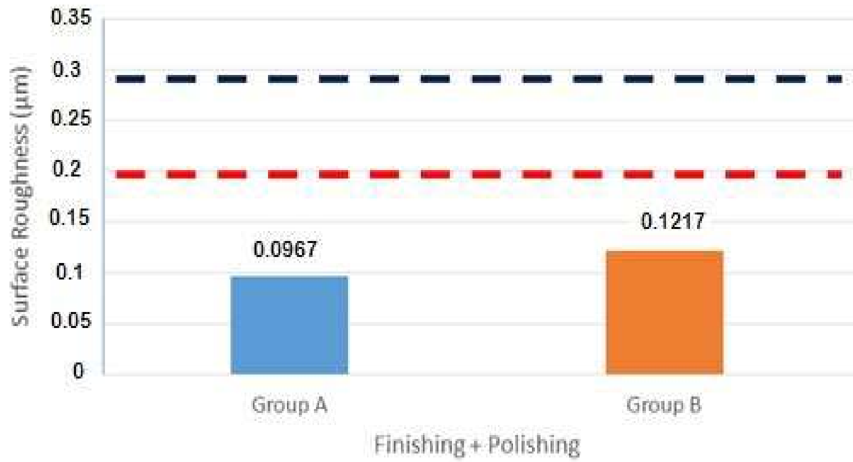


Figure 2. Surface roughness comparison between groups after the polishing procedure

- - - - (red) : Roughness felt by patient's tongue.
- - - - (dark blue) : Threshold of bacteria adherence.
Group A : Nanofilled composite resin Filtek Z350 XT
Group B : Nanohybrid composite resin Filtek Z250 XT
Finishing procedure using coarse type Sof-Lex XT Disc
Polishing procedure using a Medium, Fine, and Superfine Sof-Lex XT Disc

The independent t-test was used to analyze both groups after the polishing procedure. The normality and homogeneity tests were done beforehand. The normality test was done to determine the normality of data distribution. The Saphiro-Wilk test was used in this study because the total specimens did not exceed 50. The normality test results were significant for both group A and group B (p 0.714; 0.188; $p>0.05$). These results showed that data distribution was normal in both groups.

The homogeneity test was done afterwards to ensure that the independent t-test could be done. The homogeneity test was done to determine the similarity of variance in both groups. Test results showed that both data were homogenous (p 0.089; $p>0.05$). The independent t-test was subsequently done.

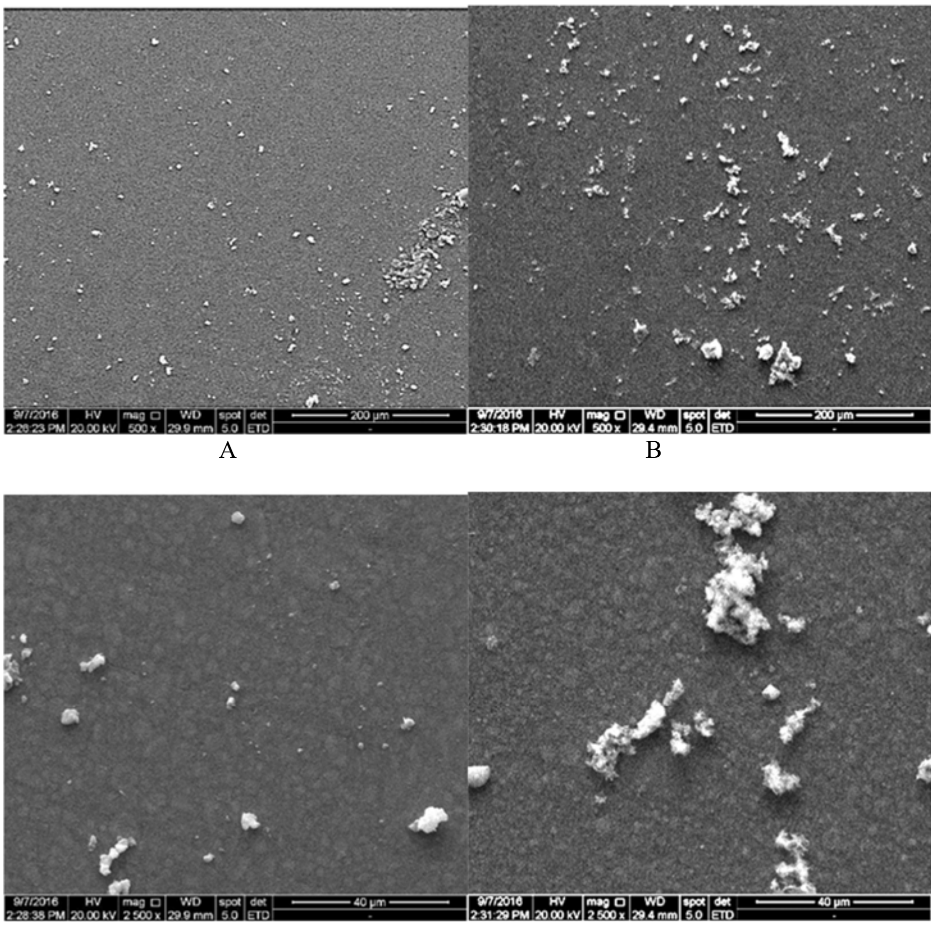
Table 1. Surface roughness means comparison between each composite resin group after the polishing procedure

Group	Surface roughness means (µm)	Standard Deviation (µm)	P
Nanofilled Filtek Z350 XT	0.0967*	0.0174*	0.001*
Nanohybrid Filtek Z250 XT	0.1217	0.0244	

Table 1 shows results from the statistical analysis of both groups using the independent t-test. The p-value was 0.001 ($p<0.05$). This indicates that there was a statistically significant difference in the means of both groups.

Results provided in Figure 2 show a surface roughness difference between the nanofilled and nanohybrid composite resins after the polishing procedure. The descriptive measurement of the nanofilled composite resin surface roughness resulted in 0.0967 ± 0.0174 µm of nanofilled composite resin surface roughness means. This result was lower than the nanohybrid composite resin which showed 0.1217 ± 0.0244 µm. The surface roughness tests in both groups showed values under 0.3 and 0.2 µm.

SEM test results also showed a different surface morphology between both groups. The test results are shown in Figure 3. Figure 3A and 3B didn't show any significant difference. However, figure 3C showed a more homogenous surface than figure 3D, which had larger and more granulated molecules (marked in red).



A B

C D

Figure 3. SEM results. Nanofilled composite resin with 500x (A) and 2.500x (C) magnification. Nanohybrid composite resin with 500x (B) and 2.500x (D) magnification

3.2 Discussion

Composite resins used in this study were nanofilled and nanohybrid because both are commonly used for tooth restoration. The finishing procedure was carried out using an aluminum oxide polishing instrument on dry conditions according to the manufacturer's instructions. The polishing procedure in this study was performed using a multi-step technique with particles of the same material varying from large to small. The polishing procedure was done immediately after finishing. Specimens were then immersed in artificial saliva to mimic the condition of the oral cavity [13].

Finishing was necessary after curing based on standard operating procedure. Both groups showed a surface roughness beyond the composite resin roughness tolerance of 0.2 µm (shown in Figure 2). This could be caused by the use of a very abrasive aluminum oxide instrument with a particle size of 50-90 µm. This indicated the necessity of the polishing procedure [14]. It was also shown in Figure 2 that the surface roughness means in group B were lower than in group A.

Endo [13] also reported rougher finishing results in the nanofilled group. According to Endo, nanohybrid surfaces with larger and irregular filler tend to be more protrusive after the curing process, and therefore finishing would produce a flatter surface [13]. On the contrary, a nanofilled composite resin with nanomer and nanocluster particles might produce few defects and scratches as a result of friction from the finishing instrument [15]. Endo suggested that it would be better for the finishing procedure to be carried out using 600-grit SiC paper or carbide bur. The study above provided surface roughness results lower than this study [13].

Table 1 showed a difference in surface roughness means between groups after the polishing procedure. This difference was statistically significant (p 0.001; $p<0.05$). It can be concluded that the hypothesis was accepted - there is a difference of surface roughness between nanofilled and nanohybrid composite resin after the polishing procedure using a multi-step technique with lower surface roughness in the nanofilled group.

These results were in accordance with previous studies conducted by Khorgami [16] and Endo [13]. Khorgami stated that the average Z350 XT composite filler size was smaller because it comprised spherical shaped nano sized particles (nanomer) combined with nanocluster particles made from the sintering process [16]. The sintering process on Filtek Z350 XT was not as adequate as the first generation of nanofilled resin; therefore the interparticle nano bond was more easily detached [16]. Furthermore, Endo stated that the spherical nanomer made from turning liquid into solid caused more filler [13]. Additionally, more load would cause the composite resin to be easily polished since more filler particles were in contact with the polishing instrument to minimalize excessive abrasion to the resin matrix [15].

During the polishing procedure, nanomer and nanocluster particles were abraded easily along with the resin matrix. The interparticle nanomer bond which constructs nanoclusters would detach, easily providing a smoother surface [17]. This was supported with the SEM photographs using different magnifications which showed a qualitatively smoother and homogenous surface. Furthermore, Filtek Z350 XT nanomer was added with silane on its surface so that it would create a strong bond with the matrix during curing. This was supported by the matrix system which contains more Bis-EMA 6 and UDMA with less double bonds, increasing the degree of resin matrix polymerization. There are a few possible explanations for higher surface roughness in Filtek Z250 XT than Filtek Z350 XT. The first possibility is larger and irregular filler size [18]. Larger and irregular filler size was obtained by grinding larger particles and causing a lot of space between fillers, which is why manufacturers add nanomer and nanocluster inside to fill the space. The larger filler would appear protrusive on the surface during curing. According to Endo, pressure would gather more on the irregular filler and increase the chance of the filler detaching from the resin surface. When the larger filler detached from the matrix, it would create a large hole on the surface and increase surface roughness. Another possible explanation for higher surface roughness is that the nanomer and nanocluster would detach first along with the softer matrix during polishing. This would increase roughness [19]

Additionally, Filtek Z250 XT still uses PEGDMA as a main matrix with more double bonds than Bis-EMA 6 and UDMA, making the curing process less adequate than Filtek Z350 XT. An inadequate curing process would create fewer polymers and a poor bond between the filler and the matrix[18]. We concluded that the larger the filler size, the higher the surface roughness after the polishing procedure.

Considering polishing instruments, Janus stated that aluminum oxide was the best polishing instrument because of its flexibility [17]. Endo concluded that aluminum oxide was still the best polishing instrument for nanofilled and nanohybrid composite resins [13].

There was a significant difference between the nanohybrid composite resin surface roughness results in this study and the study conducted by Khorgami *et al* . The results were better in this study than in Khorgami's (0.505 µm). This might be due to the difference in techniques in each study. Khorgami's study used a back and forth technique, while this study used a one way motion technique [16]. Fruits showed that a one way motion produced a lower roughness level than other motions [20].

Based on Figure 2, the surface roughness means in both groups in this study were lower than 0.2 µm and 0.3 µm. The clinical threshold of bacteria adherence was 0.2 µm while a 0.3 µm change in surface roughness could be felt with the patient's tongue [14]. Both surface roughness means were below these thresholds. These results were in accordance with Ferreira [14] and Janus [17]. Composite resins with surface roughness means below the bacteria adherence threshold could retain the composite resin's strength inside the oral cavity because it would avert the patient from secondary caries [13]. Surface roughness means below 0.3 µm could increase a patient's comfort because the smoothness of the filling material would cause no tactile perception [21].

There was a qualitative difference seen in the SEM photographs in Figure 3 between the nanofilled and nanohybrid specimens at 2500x magnification. The surface was smoother on the nanofilled composite resin with the homogenous and filler particles spreading evenly. Nanocluster particles seen on the specimen's surface were 0.5–1.5 µm in size (marked in red). Conversely, the SEM photographs of the nanohybrid specimens at 2500x magnification showed an irregular filler appearance from nano-sized to the larger 1-3 µm size. (Marked in red in Figure 3D). The results looked granulated and coarser.

4. Conclusion

There is a difference in surface roughness between nanofilled and nanohybrid composite resins after polishing using a multi-step technique. The nanofilled composite resin's surface roughness was lower compared to the nanohybrid after polishing with the multi-step technique. It is suggested that clinicians use nanofilled composite resins for anterior fillings (class IV) for their lower surface roughness and to increase esthetics. Further studies are needed to compare the surface roughness of nanofilled and nanohybrid composite resins using a different polishing technique, and to determine the effects of the polishing technique on the mechanical characteristics of composite resins.

References

[1] Bayne S C 2013 Beginnings of the dental composite revolution. *J. Amer. Dent. Assoc*. **144** 880–4.

[2] Naulita D 2015 *Perbedaan Tensile Bond Strength pada Resin Komposit Nanohybrid Menggunakan Sistem Adhesif Total-Etch dan Self-Etch pada Restorasi Klas I (Penelitian In Vitro.* (Medan: Fakultas Kedokteran Gigi Universitas Sumatera Utara) p 6-10.

[3] Jain A *et al*. 2015 Evaluation of microleakage of recent nano-hybrid composites in class v restorations: an in vitro study. *Int. J. Adv. Health. Sci*. **2** 8-12.

[4] Sakaguchi R L and Powers J M 2012 *Craig's restorative dental materials*. 13th ed. (St. Louis, Mo.: Elsevier/Mosby) **84** 162-81.

[5] Spiller M S 2012 Dental composites: a comprehensive review. *Acad. Dent. Learn. OSHA. Train.* **23** 1-36.

[6] Erdemir U, Sancakli H S and Yildiz E 2012 The effect of one-step and multi-step polishing systems on the surface roughness and microhardness of novel resin composites. *Europ. J. Dent.* **6** 198-205.

[7] Venturini D, Cenci M S, Demarco F F, Camacho G B and Powers J M 2006 Effect of polishing techniques and time on surface roughness, hardness and microleakage of resin composite restorations. *Oper. Dent*. **31** 11–7.

[8] Howard E 2010 Current concepts for polishing anterior composite resins. *ADA Continuing Education Recognition Program. Insical. Edge.* (Pennsylvania, US: Benco Dental) p. 97–108.

[9] Nair V S, Sainudeen S, Padmanabhan P, Vijayashankar LV, Sujathan U and Phillai R 2016 Three-dimensional evaluation of surface roughness of resin composites after finishing and polishing. *J. Conserv. Dent.* **19** 91-5.

[10] Takamizawa T, Watanabe *et al*. Influence of polishing duration on surface roughness of composite resins. *J. Oral Sci*. **47** 21–5.

[11] Costa J D, *et al*. 2007 The effect of different polishing systems on surface roughness and gloss of various resin composites. *J. Esthet. Restor. Dent*. **19** 214–26.

[12] Ergucu Z, Turkun L S 2007 Surface roughness of novel resin composites polished with one-step systems. *Oper. Dent.* **32** 185-92.

[13] Endo T, Finger W J, Kanehira M, Utterodt A and Komatsu M 2010 Surface texture and roughness of polished nanofill and nanohybrid resin composites. *Dent. Mater. J.* **29** 213-23.

[14] Ferreira *et al*. Impact of novel polishing method on the surface roughness and micromorphology of nanofilled and microhybrid composite resins. *Rev Port Estomatol Med Dent Cir Maxilofac*. **5/6** 18-24.

[15] Attar N, *et al*. 2007 The effect of finishing and polishing procedures on the surface roughness of composites resin materials. *J. Contemp. Dent. Pract.* **8** 27-35.

[16] Khorgami K, Sadaghiani M and Nemati S. In vitro comparison of the impact of four types of resin composite on the repaired bond strength and surface roughness after sandblasting. *J. Res. Dentomaxillofac Sci*. **1** 9–16.

[17] Janus J, Fauxpoint G, Arntz Y, Pelletier H and Etienne O 2010 Surface roughness and morphology of three nanocomposites after two different polishing treatments by a multitechnique approach. *Dental Mater*. **26** 416–25.

[18] Senawongse P *et al*. 2007 Surface roughness of nanofill and nanohybrid resin composites after polishing and brushing. *J. Esthet. Restor. Dent.***19** 265-75.

[19] Patel B, Chhabra N and Jain D 2016 Effect of different polishing system on the surface roughness of nanohybrid composites. *J. Conserv. Dent*. **19** 37-40.

[20] Fruits T J, Miranda F J and Coury T L 1996 Effects of equivalent abrasive grit sizes utilizing differing polishing motions on selected restorative materials. *Quintessence Int*. **27** 279-85.

[21] Jones C S, Billington R W and Pearson G J 2004 The in vivo perception of roughness restorations. *Br. Dent. J.* **196** 42–5.