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The Efficiency of a New Polishing Material: Nanotechnology Liquid Polish

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Clinical Relevance

It is well known that the esthetic properties and clinical stability of resin composites are increased by finishing and polishing procedures. However, there is still a question of which techniques or materials should be preferred. The use of nanotechnology may be the best way of creating more esthetic composite restorations.

SUMMARY

Introduction: This study evaluated the efficiency of a nanotechnology liquid polish system on the surface roughness of two different types of nano resin composites.

Methods and Materials: The resin composite materials tested in this study were Ceram-X (Dentsply) and Clearfil Majesty Esthetic (Kuraray). Forty standard samples of each resin composite material were prepared and stored in artificial saliva at 37°C for one week. The samples of each material were randomly assigned to one of four test groups (n=10) and contoured with carbide burs, except for Group 1 (control). Group 2 was treated with aluminum oxide-impregnated polymer points (Enhance Finishing System, Dentsply), followed by diamond-impregnated micropolishing points (PoGo, Dentsply); whereas Group 3 was treated with only a nanotechnology liquid polish system (Lasting Touch, Dentsply) and Group 4 was treated with aluminum oxide-impregnated polymer points and diamond-impregnated micropolishing points, then the nanotechnology liquid polish system. Surface roughness values (Ra) of all samples were obtained with an optical profilometer. The difference between the groups was assessed with one-way analysis of variance and the Kruskal Wallis test.

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Results: All finishing and polishing techniques created statistically rougher surfaces than the control group (*p*<0.001). The lowest Ra values were detected in Group 4, although significant differences were not found between Groups 2 and 4 (*p*>0.001) independent of the type of resin composites.

Conclusion: With the combination of finishing and polishing procedures, a nanotechnology liquid polish application may provide a more glossy surface for resin composite restorations.

INTRODUCTION

Esthetic requirements are forcing manufacturers and dental professionals to perform more studies with respect to restorative materials and handling techniques. Several changes have been made in the fabrication of dental resin composites to achieve better color stability, greater wear resistance and acceptable surface smoothness of restorations.[1] Recently, nanofilled and nano-ceramic resin composite materials have been manufactured and are available as a result of recent developments in nanotechnology. Nanotechnology was first used in dentistry in 1997. It offers the opportunity for designing restorative materials with new characteristics.[2-3] The advantage of nanotechnology is an increase in the polishing capacity and clinical success of restorative materials by using finer filler particles.[4-5] Nanofilled resin composite materials are formulated with nanomer and nanocluster filler particles combined with a conventional resin matrix.[1,4,6] In 2003, manufacturers combined nanotechnology with methacrylate-modified polysilocxane and the result was nano-ceramic technology.[5]

It is well known that the esthetic properties and clinical stability of resin composites are increased by finishing and polishing procedures. Smooth, highly polished restorations have been shown to be more esthetic and more easily maintained than restorations with rougher surfaces.[1,6,8] Additionally, material surfaces are prone to discoloration and plaque accumulation, while teeth are susceptible to gingival irritation and secondary caries after inadequate polishing procedures.[1,8-9] Also, surface roughness may directly influence the wear behavior and marginal integrity of resin composite restorations.[1,6,10] Therefore, maintaining the smooth surface of a restoration is a factor in its success.[4,6,11]

Today, the removal of excess materials, recontouring and surface polishing are generally performed during the placement of resin composite restorations. As a result, a wide variety of finishing and polishing devices are available, including diamond and carbide burs, abrasive impregnated rubber cups and points, aluminum oxide-coated abrasive disks, abrasive strips and polishing pastes.[2,6,12] Recently, liquid polishers have been used to optimize surfaces. Liquid polishers are low-viscosity fluid resins that provide a gloss over resin composite restorations, improving final esthetics. A further objective of liquid polishers is to create a marginal seal, with the ability to fill microgaps and reduce microleakage at composite margins. Liquid polishers can be applied to posterior and anterior teeth, where good esthetics is required. However, none of the liquid polishers currently marketed meet all of the requirements. Recently, a nanotechnology liquid polish was designed to overcome the limitations of liquid polishers. According to the manufacturer's data, the addition of nanofillers provides excellent results. However, no scientific studies of this claim were found.

This *in vitro* study evaluated the efficiency of a nanotechnology liquid polishing system on the surface roughness of two different types of resin composites manufactured using nanotechnology.

METHODS AND MATERIALS

The resin composite materials tested in the current study were Ceram-X (Dentsply, York, PA, USA, nanoceramic resin-matrix composite) and Clearfil Majesty Esthetic (Kuraray, Tokyo, Japan, nanofilled resin-matrix composite). Forty samples of each material were prepared utilizing a plastic mold (10 mm in diameter x 2 mm thick). The mold was slightly over-filled with material, covered with a Mylar matrix strip (Yates and Bird/Motloid, Chicago, IL, USA) and pressed flat between two glass slides. The specimens were then polymerized with a light-curing unit for 40 seconds (LED LCU, Elipar Freelight, 3M ESPE, St Paul, MN, USA). After light curing, all the specimens were stored in artificial saliva at 37°C for one week. The samples of each material were randomly assigned to one of four test groups (n=10). Group 1 was used as a control, without performing any of the finishing or polishing procedures. In an attempt to mimic the clinical situation, all samples were contoured with carbide burs, except for Group 1. All the Group 2 samples were treated with aluminum oxide-impregnated polymer points (Enhance Finishing System, Dentsply), followed by diamond-impregnated micropolishing points (PoGo, Dentsply). Group 3 was treated using only a nanotechnology liquid polish system (Lasting Touch, Dentsply) applied according to the manufacturer's directions. Finally, Group 4 was treated with the Enhance finishing system, PoGo micropoints and a nanotechnology liquid polish (Table 1). Specimen preparation, finishing and polishing procedures were carried out by the same operator to reduce variability. All the specimens were finished and polished using a slow-speed handpiece with water spray, while the disks, burs and points were discarded after each use.

Table 1: *The Resin-matrix Composites and the Surface Treatment Protocols Examined in the Study*

Resin Composites	**Type of Material**	**Manufacturer**
1. Ceram-X	Nano-ceramic resin-matrix composite	Dentsply, York, PA, USA
2. Clearfil Majesty Esthetic	Nano-filled resin-matrix composite	Kuraray, Tokyo, Japan
Surface Treatment Protocols	**Type of the Material**	**Manufacturer**
Group 1.		
1. Under Mylar Matrix	Mylar matrix	Yates and Bird/Motloid, Chicago, IL, USA
Group 2.		
1. Carbide Burs		
2. Enhance Finishing System	Aluminum oxide impregnated polymer points	Dentsply, York, PA, USA
3. PoGo Micropoints	Diamond impregnated micropolishing points	Dentsply, York, PA, USA
Group 3.		
1. Carbide Burs		
2. Lasting Touch	Nanotechnology liquid polish	Dentsply, York, PA, USA
Group 4.		
1. Carbide Burs		
2. Enhance Finishing System		
3. PoGo Micropoints		
4. Lasting Touch		

Table 2: *The Means of the Surface Roughness Values (Ra)*

Groups	Clearfil Majesty Esthetic	Ceram-X	Total
Group 1 (Control)	0.08 (0.06-0.21)a	0.04 (0.03-0.05)b	0.06 (0.04-0.08)
Group 2	0.76 (0.71-0.82)A	0.69 (0.52-0.82)A	0.75 (0.62-0.82)‡
Group 3	1.03 (0.96-1.08)B	0.94 (0.83-1.01)B	0.97 (0.90-1.06)‡,#
Group 4	0.75 (0.61-0.80)A	0.60 (0.54-0.71)A	0.66 (0.58-0.79)‡

Means followed by different lower-case letters are different from each other at the level of 0.1% within each row.
Means preceeded by different capital letters are different from each other at the level of 0.1% within each column.
‡Statistically different from control group (p<0.001)
#Statistically different from Group 2 and Group 4 (p<0.001)

Surface Roughness Test

Surface roughness values (Ra) of all samples were obtained using an optical profilometer (Perthometer Unit, L_T= 5.6 mm, λ_c= 0.8 mm, Mahr GmbH, Göttingen, Germany). Three tracings were recorded on each specimen perpendicular to the finishing and polishing scratch directions, and the average of these three Ra measurements was determined as the final Ra score for each specimen. The significance of the difference with respect to mean Ra values among the groups was assessed with one-way analysis of variance (ANOVA) or the Kruskal Wallis test. In addition, the Tukey test was used, where the results of ANOVA was significant. The level of significance was set at p<0.001.

Scanning Electron Microscope (SEM) Studies

Representative samples with Ra scores close to the mean values were selected from each group, coated with gold and examined under SEM (JSM-5600, JEOL, Tokyo, Japan) observation in

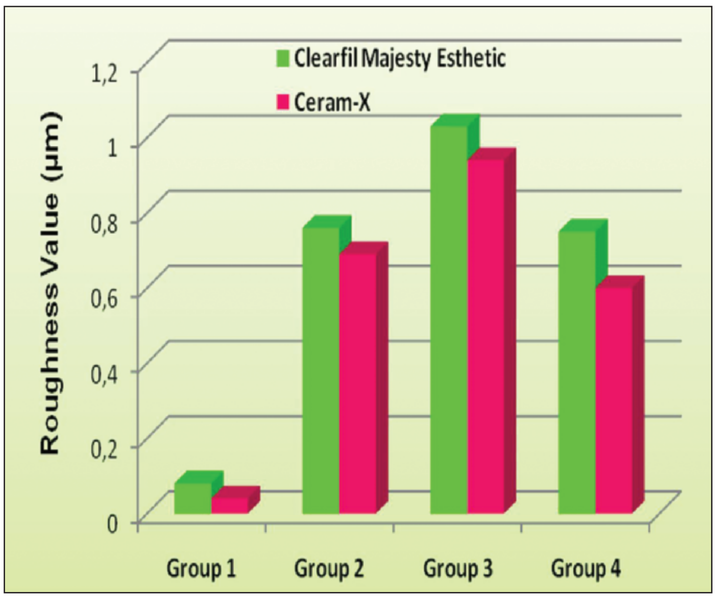

Figure 1. *Changes in the surface roughness values.*

Figure 2. *Scanning electron micrographs of the topographic surfaces of resin-matrix composites.*

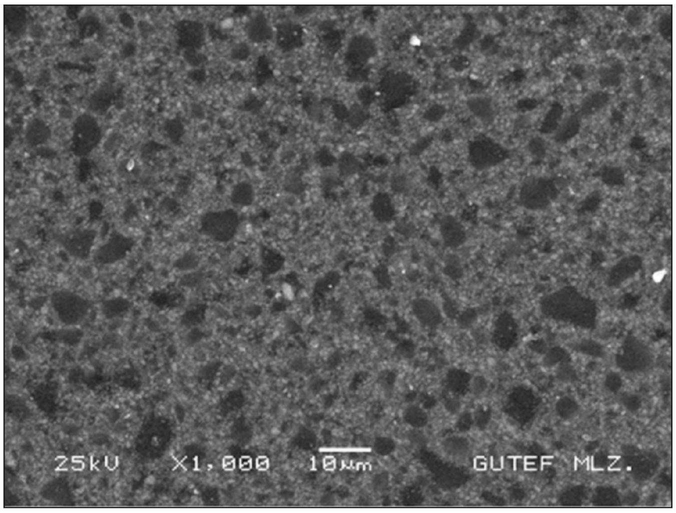

Figure 2A. *Clearfil Majesty Esthetic; Control*.

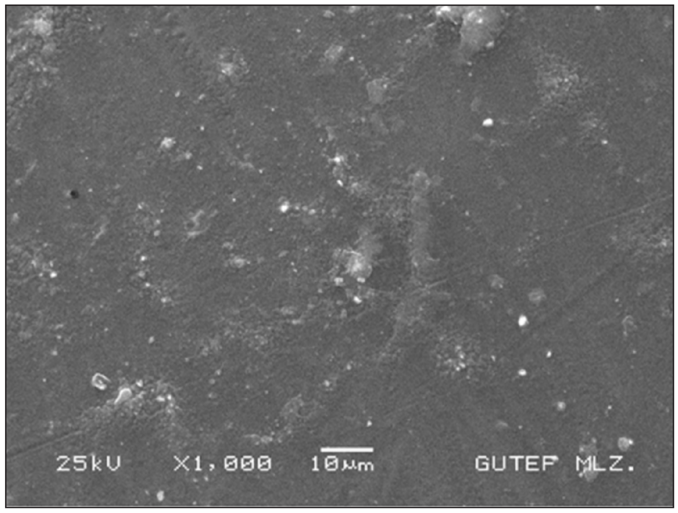

Figure 2B. *Clearfil Majesty Esthetic; Group 2.*

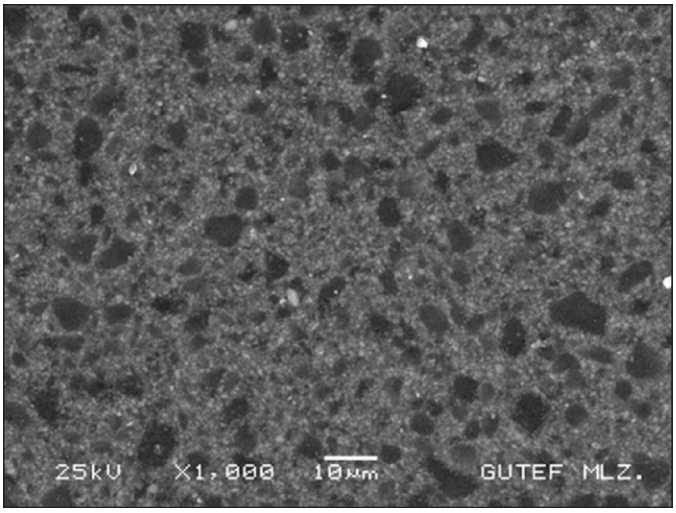

Figure 2C. *Clearfil Majesty Esthetic; Group 3*.

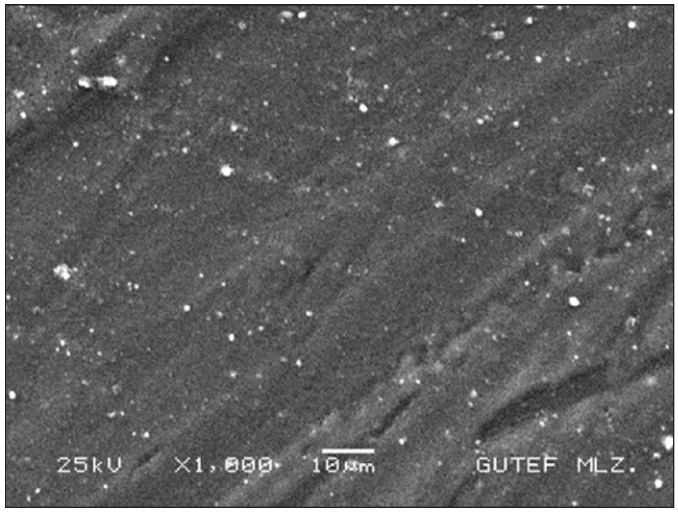

Figure 2D. *Clearfil Majesty Esthetic; Group 4.*

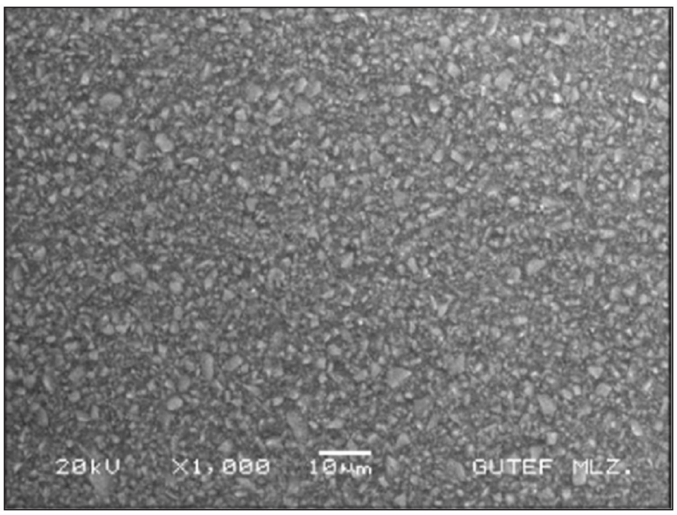

Figure 2E. *Ceram-X; Control*.

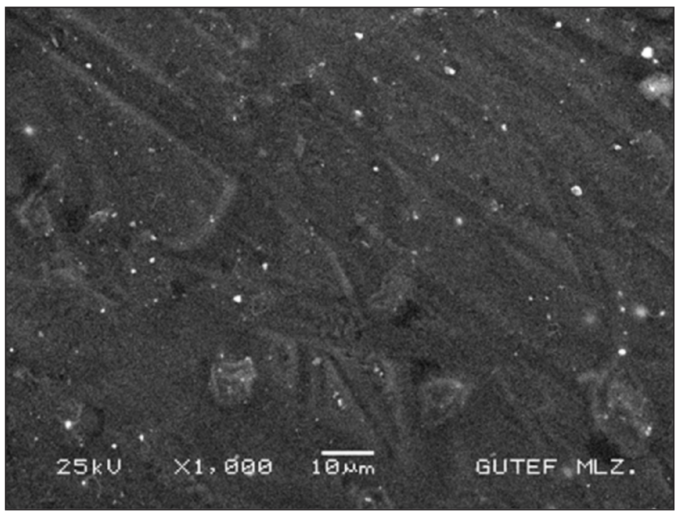

Figure 2F. *Ceram-X; Group 2.*

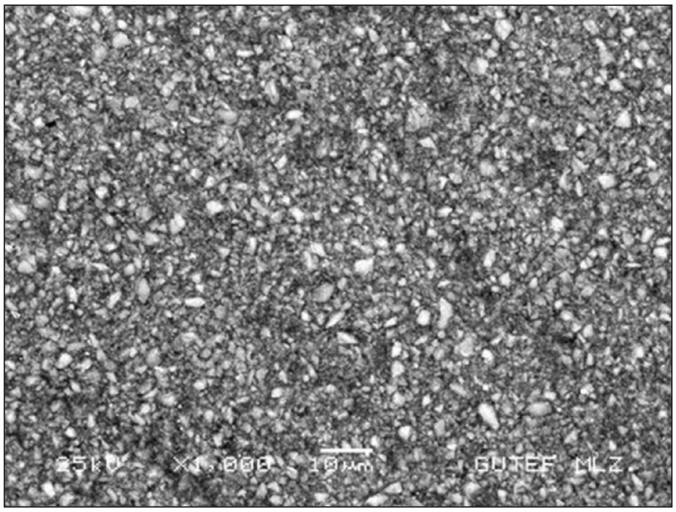

Figure 2G. *Ceram-X; Group 3.*

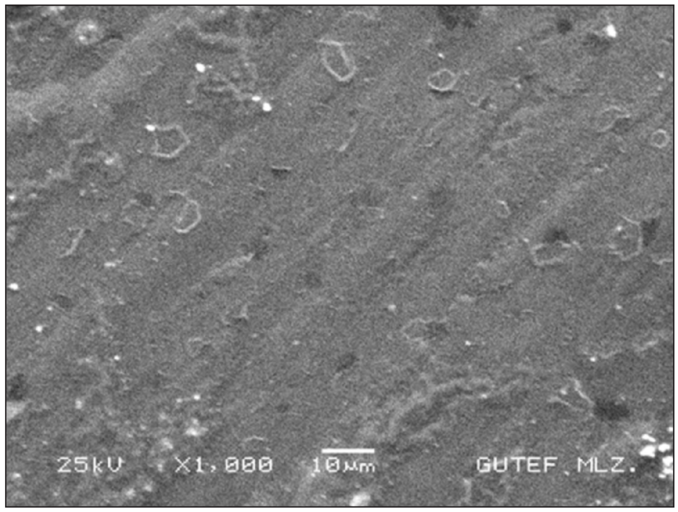

Figure 2H. *Ceram-X; Group 4.*

order to document the surface texture created by different polishing procedures. SEM photographs were taken at 1000x and 2500x magnifications to compare the surface topographies.

RESULTS

The mean and standard deviations of surface roughness values (Ra, µm) are shown in Table 2 and Figure 1.

The smoothest surfaces were obtained under the Mylar matrix (control groups), which is independent of the type of resin composite (p<0.001).

All of the finishing and polishing techniques created statistically rougher surfaces than both control groups (p<0.001).

When the surface roughness values of the control groups were compared according to resin composite types, the lowest values were found with the nano-ceramic samples (p<0.001).

When the finishing systems were compared, no significant differences were observed between resin composite types for each of the procedures (p>0.001).

The ranking of the mean Ra values by finishing and polishing systems for both resin composite types were as follows: Group 1 (Control) < Group 4 < Group 2 < Group 3. The analysis showed that there was a statistically significant difference among all groups (p<0.001), except between Group 2 and Group 4 (p>0.001).

The highest Ra values were found with the combination of nanofilled resin composite samples and Group 3 (p<0.001), while the lowest mean scores were detected in Group 4 combined with the nano-ceramic samples.

SEM photographs in correlation with surface roughness values are shown in Figure 2. SEM evaluation of surface-polished composite specimens revealed different textures.

The smoothest surfaces were obtained from the unpolished samples of the nanofilled and nano-ceramic resin composites (Figures 2A and 2E).

The roughest surfaces were presented using the nanotechnology liquid polish (Figures 2C and 2G).

Use of the Enhance finishing system and PoGo micropoints, followed by a nanotechnology liquid polish (Figures 2D and 2H), provided the smoothest surfaces in the experimental groups.

Use of the Enhance finishing system and PoGo micropoints (Figures 2B and 2F) created similar surface textures with use of the Enhance finishing system and PoGo micropoints, followed by nanotechnology liquid polish for both of the experimental groups.

DISCUSSION

The efficiency of finishing and polishing procedures on resin composite surfaces is an important factor affecting the esthetic properties and long-term success of restorations. The current study attempted to evaluate the efficiency of current finishing and polishing systems on nanotechnology resin composites.

Mechanical profilometers are generally used to evaluate surface roughness for *in-vitro* studies. Although this method provides somewhat limited two-dimensional information, an arithmetic average roughness is calculated and used to represent various material and polishing combinations that can provide information to clinicians for their decisions in terms of which finishing method to use.[4-5] For this reason, an arithmetic average roughness was preferred to evaluate surface roughness in the current study.

It is well known that, because of the resin rich layer, the smoothest surfaces are formed with Mylar strip-formed surfaces.[12] The current results were in agreement with this finding, reporting the smoothest surfaces were produced with Mylar matrix for both the nanofilled and nano-ceramic resin composite groups. These surfaces against a matrix were smoother than the polished surfaces, because the unpolished surfaces contain more polymer matrix than fillers.[6] However, the nano-ceramic resin composite provided a smoother surface than nanofilled samples against Mylar matrix. Nanofilled composite nanomers are discrete nano-agglomerated particles 20-75 nm in size, while nano-clusters are loosely bound agglomerates of nano-sized particles.[4] With this technology, the percentage of filler particles in the resin matrix comprises 80% of the total weight.[7] Most of the current studies suggest that the combination of nano-sized particles and nanocluster formulations reduces the interstitial spacing of filler particles and, therefore, provides increased filler loading, better physical properties and improved polish retention.[1,4,7] On the other hand, nano-ceramic resin composites include glass fillers 1.1–1.5 µm in size, thus comprising 76% of the total weight. According to studies, the use of nano-ceramic technology offers superior esthetics and handling properties. It is well-known that, as the size of filler particles is decreased and the percentage by weight is increased, the esthetic properties and polishing capacity of a material improves.[1,5-7] In the current study, the nano-ceramic resin composite samples exhibited significantly lower levels of surface roughness than the nanofilled samples against Mylar matrix. This result may be explained due to the composition diversity and filler particle size of the nano-ceramic.

As certain studies have shown,[14-15] the surface layer, which is rich in resin, needs to be eliminated, making finishing indispensible. Jung[16] suggested that carbide-finishing burs would be best suited for finishing. Ferracane and others[17] reported that finishing using diamond burs tended to leave a more irregular surface when compared with finishing using carbide burs. Therefore, carbide burs were used in the current study to finish the outer surfaces of samples prior to performing the different polishing techniques.

Although all polishing systems have advantages and disadvantages, their efficiency with respect to producing smooth surfaces, is different.[12] This difference comes from the individual properties of these systems as well as the formulations of resin composite materials. The type of inorganic filler, the size of the particles and the extent of the filler loading varies widely among these materials, which influences their polishability.[4] In addition to the resin matrix and inorganic filler differing in hardness, different materials do not abrade uniformly.[9] The surface smoothness of nanofilled and nano-ceramic resin composites was not significantly different after finishing and polishing with the tested systems (Table 2). The current study showed that, for both resin composites, significantly greater Ra values were found with the separate use of a nanotechnology liquid polish. The use of the Enhance finishing system and PoGo micropoints, followed by nanotechnology liquid polish, provided the smoothest surfaces, which were not significantly different than when compared to use of the Enhance finishing system and PoGo micropoints. In a study by Scheibe and others,[18] the use of PoGo micropoints after using the Enhance finishing system resulted in better surface smoothness for nanofilled resin composites than silicon rubbers followed by a diamond paste. Again, Türkün and Türkün[19] revealed that PoGo micropoints produced the smoothest finishing for all resin composites. These findings are in accordance with a study that indicates finishing with PoGo created smoother surfaces than Sof-Lex discs for resin composites.[1] In light of the above studies, the current study combined the Enhance finishing system with PoGo micropoints in order to refine the polishing.

It was concluded that the smoothest finish, according to the Ra values for nanotechnology resin composites, was achieved either with or without the application of nanotechnology liquid polish. On the other hand, the combination of systems presented the lowest Ra values for both resin composites when compared to separate usage. Similar to the current study, Reis and others[20] showed that the smoothest surfaces were recorded when a final paste or polish was applied. In agreement with these findings, Attar[4] showed that use of the Enhance finishing system, followed with a liquid polish, significantly improved the surface smoothness of all tested resin composites. Saraç and others[22] also revealed that use of a liquid polish material after polishing discs or polishing wheels resulted in significantly lower Ra values when compared to single usage of each finishing and polishing technique.

On the other hand, there are currently no available studies regarding nanotechnology liquid polish. Investigators revealed that most liquid polishers have poor wear resistance, most products stain due to the color of the coating or by wear/staining of the material over time, some products debonded from the substrates shortly after application due to weak adhesion of the coating to substrates and many products cannot be cured by LED lights.[21] According to the manufacturer's data, nanotechnology liquid polish is designed to overcome these limitations, with the addition of nanofillers, while providing a glossy surface on direct or indirect resin composite restorations. Because of its unique chemistry, nanotechnology liquid polish can be cured by both LED and halogen lights. Ease of use and esthetic activity that can be seen with the naked eye are advantages of this nanotechnology liquid polish.

In the current study, the use of a nanotechnology liquid polish after finishing and polishing procedures had a positive effect on surface topographic properties for both composite types, according to SEM examinations. Although comparable results were obtained and the ultrastructure, size, volume of the microgaps and defects were decreased, esthetic properties were developed by the additional use of a nanotechnology liquid polish. This can be explained, as the polish appears to fill the structural microdefects and provide a more uniform, regular surface.

From the current study, the application of a nanotechnology liquid polish after finishing and polishing procedures may provide even better results. However, there is no available scientific paper covering nanotechnology liquid polish. Therefore, further *in-vivo* and *in-vitro* studies are needed, where all of the liquid polishers and a combination of different finishing techniques can be tested.

CONCLUSIONS

It was concluded that no statistical differences were observed for Ra values between the Enhance finishing system followed by PoGo micropoints and the combination of systems and nanotechnology liquid polish. On the other hand, as a final step, application of a nanotechnology liquid polish could improve the esthetic properties and clinical success of resin composites, based on SEM examinations.

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