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Evaluation of Different Finishing/Polishing Systems of a Nano-Hybrid Resin Based Composite Restorations

Ahmad S. Al-Ghamdi 1, Mohammed A. Al-Ateeg 1, Mohammed G. Al-Otaibi 1, Nashaat M. Magdy 2

1 *Intern, College of Dentistry, Prince Sattam Bin Abdulaziz University, KSA*
2 Assistant Professor of Conservative Dental Science, College of Dentistry, PrinceSattam Bin Abdulaziz University, KSA
Corresponding author: Ahmad S. Al-Ghamdi

Abstract:
Objectives: This study was conducted to evaluate quantitavely and qualitatively the effect of different Finishing/Polishing systems of a nano-hybrid resin-based composite.
Materials and Methods: Forty cylindrical split molds (10 mm diameter and 2 mm thick) were constructed from Teflon. Three groups of a nano-hybrid resin-based composite specimens were prepared; ten per each Finishing/Polishing systems (n=10) and ten unpolished as a control. The specimens were tested quantitatively by profilomerty and qualitatively by atomic force microscope.
Results: a significant difference was observed among polishing procedures (P<.0001). The highest roughness values were recorded for all the restorative material polished with one step system. There was no any polishing system could produce smooth surface similar to Mylar strip.
Conclusions: Liquid polisher exhibited the least surface roughness among the tested polishing systems but still worse than Mylar strip.

Keywords: *Finishing/Polishing, Nano-hybrid composite, Surface roughness, Surface sealant, Atomic Force Microscope.*

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I. Introduction

The esthetic appearance of tooth-colored restorations is of great interest to both dentist and patient. To reach the goal of restoring teeth with natural appearance, developments of restorative technology are evolved into two fold approaches. The first approach is development in filler size, while the second approach is development in finishing and polishing technology. Regarding to filler size, various new composites, based on nanotechnology, have been developed with the aim of combining the advantages of hybrid and microfilled restorative materials. These materials are claimed to offer reduced polymerization contraction, enhanced mechanical characteristics, and improved esthetics.[1-4] Nanofill composites are formulated with both nanomer and nanocluster filler particles, whereas nanohybrid composites are hybrid resin composites containing finely ground glass in a prepolymerized filler form and nanofiller.[5]

Proper finishing and polishing of dental restorations are important aspects in clinical restorative procedures, regardless of the type and location of the restoration, because they enhance both esthetics and longevity of restored teeth.[6-7] Residual surface roughness, associated with improper finishing and polishing, can result in a number of clinical problems such as excessive plaque accumulation,[8,9] gingival irritation, increased surface staining, suboptimal esthetics of the restored teeth[10], marginal leakage and secondary caries. [11, 12] Therefore, maintaining the smooth surface of a restoration is of great important for its success.

Surface roughness influences resistance to staining[11,12]and the natural gloss of the restoration.[13,14] The most smooth and glossy surface is generally obtained under a Mylar strip without subsequent finishing or polishing, but unfortunately intra-oral finishing is always required. [15] The mylar strip finished surface has higher resin content and will reduce the wear resistance of the restoration over time. Therefore, finishing and polishing of tooth-coloured restoration after placement are inevitable procedures that will improve esthetics; early wear resistance, color stability and marginal integrity. [1, 16] Several investigations have shown that removal of the polymer-rich, outermost resin layer is essential to achieving a stain-resistant, more esthetically stable surface. [17-19]

Clinicians have their choice among a wide range of finishing and polishing instruments. The search for the ideal polishing system for dental composites is ongoing. [20] With the ultimate goal of achieving a smooth surface of the composite restoration in fewer steps, current one-step systems appear to be as effective as multi-step systems for polishing dental composites[6]. The one-step polishing systems are appealing to the clinician. [21]

Liquid polishers (surface sealant) are low viscosity fluid resins that provide a gloss over composite resin restoration, improving final esthetics and reducing microleakage at composite margin.[22-24] Surface sealants have also been shown in vitro to help prevent stain penetration and discoloration of composite resins, and to result in greater shade stability.[25, 26] This procedure takes only a few seconds of chair side time.

This study was conducted to investigate quantitavely and qualitatively surface roughness of a nano-hybrid resin-based composite finished/polished with different systems. The null hypothesis was; there were significant differences among polishing systems used.

II. Materials & Methods

Three different polishing systems were used for a nano-hybrid resin based composite (Tetric N Ceram); multi-steps system (Astropol), one- step system (Astrobrush) and liquid polisher (G-coat Plus). Brand names, specifications, manufacturers and compositions of the tested restorative material and polishing systems are listed in Table 1.

Table 1: materials used in the study:

Brand names	Specificatioin	Manufacture	Composition
Tetric N ceram	*Nano hybrid composite*	*IvoclarVivadent*	*Matrix: bisGMA,UDMA,TEGDMA,EthoxylatedBis-EMA.* *Filler:Barium glass, ytterbium trifluoride,mixed oxide, silicon dioxideprepolymers*
A stropol *F* *P* *HP*	*Three step polishing system*	*IvoclarVivadent*	*Matrix:rubber* *Abrasive:siliconcarbid, aluminiumoxide, titanium oxide, ferrous oxide, diamond dust(HP)*
Astrobrush	*One step polishing system*	*IvoclarVivadent*	*Silicon carbide-impregnated polyamide bristle brush*
G-coat Plus	*Nano-filled self-adhesive light cured protective coating*	**GCcorporation Tokyo, japan**	*Urethane methacrylate, methylmethacrylate, camphorquinone, silicon dioxide, phosphoric ester monomers*

Cylindrical split mold (50 mm diameter and 2 mm thick) was constructed from Teflon. In the center of the mold a circular recess (10 mm diameter) was constructed and used for preparing Tetric N Ceram specimens. The material was placed in bulk in the mold using Optra Sculp (Ivoclar Vivadent AG, Schaan, Liechtenstein) modeling instrument over a transparent, 0.051 mm thick Mylar strip (Universal strip of acetate foil, Italy) and a glass slide. Black paper was placed between the glass slide and Mylar strip to prevent reflection of light during polymerization.27 Effort was made to prevent the inclusion of air voids while inserting the material in the mold. Another Mylar strip and a glass slide one mm thick were placed over the inserted material. A 500 gm stainless steel weight was applied for 30 s over the specimen, allowing the composite to flow in order to obtain a smoother and standardized surface.

After removal of the weight, curing was performed according to manufacturer's instructions. Only one operator performed all the procedures of specimen's preparations. A light emitting diode (LED) visible-light curing unit (bluephase C8, Ivoclar Vivadent AG, Schaan, Liechtenstein) was used, and the power density of the light (800 mW/cm2) was checked every 10 specimens with a digital readout dental radiometer (blue phase meter, Ivoclar Vivadent AG, Schaan, Liechtenstein). The distance between light source and specimen was standardized by curing through the glass slide. The tip of the light curing unit was in contact with the covering glass slide. Finally the specimens were removed from the mold. The specimens were immediately finished and polished to simulate the clinical condition.

Three groups of specimens were prepared, one for each finishing/polishing system (n=40). Ten specimens were remained without finishing/polishing after removal of mylar strip and used as a control group. Specimens were finished with fine grit diamond instrument to simulate clinical condition for 30 s with a high-speed handpiece under water cooling. A new finishing bur was used for every five specimens.[28]

For group I, the specimens were finished and polished with three steps silicon system, following a decreasing sequence of abrasiveness (the Astropol F(Finishing), the Astropol P (Polishing) and the Astropol HP

(High Polishing) polishing discs using a low- speed hand piece at approximately 10,000 rpm in conjunction with water spray. Uniform light pressure and a planar motion 10 s for each abrasive step were used to polish the specimens122. After each polishing step, the specimen was rinsed with water spray and blow dried with an air syringe. For group II, the specimens were polished using astrobrush for 30 s (one-step system) which was mounted on a low speed handpiece attached to an electrical motor to fix the speed at 10000 rpm in conjunction with water spray. Each brush was removed after single use. For group III, the specimens were coated with liquid polisher (G-coat Plus) after finishing with diamond instruments.

After the finishing/polishing procedures, the specimens were washed with air-water spray for 5 s and examined under a stereomicroscope for grinding debris or surface defects. If voids were present, the specimen was discarded and replaced with another then stored in distilled water at room temperature for 24 hours to complete the polymerization.[29]

Surface roughness was measured using a portable surface texture measuring instrument (Surftest SJ-201 P, Mitutoyo Corporation, Japan). A diamond stylus with tip radius 5 µm was used in the measurements, this diamond stylus mounted in a detector. The detector moved over the specimen by a driving speed 0.25 mm/s for a measured length 4.0 mm and with 900 angles. Each specimen was mounted to the V-block of the surface roughness tester and fixed with fixing jaw.

The measured roughness parameter was the average roughness height of the surface (Ra). Profile tracings of representative specimens were obtained at X 1000 vertical and X 50 horizontal magnifications. Three readings were taken for each specimen and the mean of each specimen was calculated.

One specimen from the control group and each F/P system were selected randomly to qualitatively evaluate Ra with Atomic Force microscope (AFM). A Digital Instrument Thermo microscope AFM (Autoprobcp, Santa Barbara, CA, USA) was used to measure Ra of the selected specimens from each group. For this study we used the contact mode in which a sharp silicon nitride tip is scanned over the specimen surface with a very light force of about 7-10 N. The specimens were mounted with cyanoacrylate adhesive on a piezoceramic tube that provided three-dimensional motion of each specimen with sub-nanometer accuracy. As the specimen was scanned at constant force, the three-dimensional motion of the piezoceramic tube was recorded as an image and corresponded to the surface morphology. The scanner covers area of 150 X 150 µm2 at the maximum and has the dynamic range of 12 µm in vertical direction.

The AFM image was captured for an area 20 µm2 using scanning speed of 80 µm in air. The in-plane resolution of the AFM is dictated by radius of curvature of the tip (about 20 nm as measured by AFM), while the vertical resolution is about 0.1 nm. AFM images were collected at a very low scan rate of 1.0 Hz in order to obtain details of the specimens and to avoid damaging the tip. Analysis of AFM images were performed using the Park Scientific Instruments Software Package supplied with the AFM instrument.

The collected data were down loaded to a computer using Microsoft Excel Version 7 and statistical analysis was performed using the SPSS statistical package (Statistical Package for the Social Science; SPSS Inc, Chicago, IL, USA).

III. Results

The Ra mean values and standard deviation of nano hybrid resin composite material against Mylar strip and after polishing with either three systems were obtained through the analysis of 2–D profilometer reading. Statistical evaluation of the data was performed with one way ANOVA to evaluate the effect of different polishing systems on dental resin composite tested, and their interaction on surface roughness. It was found that there was a significant effect of finishing method on surface gloss; table 2.

Regarding to polishing methods tested, a significant difference was observed among polishing procedures. A Mylar strip was used as the control, and the surface roughness values for all polishing systems were compared to that of the Mylar strip as it has the lowest roughness mean values (0.071) to be followed by liguid polisher 0.096) to be followed by three step system (0.126). The highest roughness values were recorded for all the restorative material polished with one step system (0.202). There was no any polishing system could produce smooth surface similar to Mylar strip.

Materials	Mylar	Three-step system	one-step system	Liquid polisher	LSD	P value
Nanohybrid	**0.071±0.0035**	**0.126± 0.0035**	**0.202 ± 0.019**	**0.096± 0.0035**	**.009**	**<0.0001**
LSD	**.0031**	**.00032**	**.014**	**.0032**		
P value	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**		

Table 2: Mean Ra (µm) and standard deviation for the tested composite material after different finishing /polishing procedures

The quantitative analysis by 2-D profilometer was in agreement with the qualitative analysis of the selected specimens by AFM. With mylar strips, relatively uniform surface topography were obtained, while when the specimens subjected to polishing procedures, AFM examination revealed, scratch lines from using polishing system, surface irregularities and filler dislodgement on the material surfaces were also observed to varying degrees according to polishing system; Fig 1.

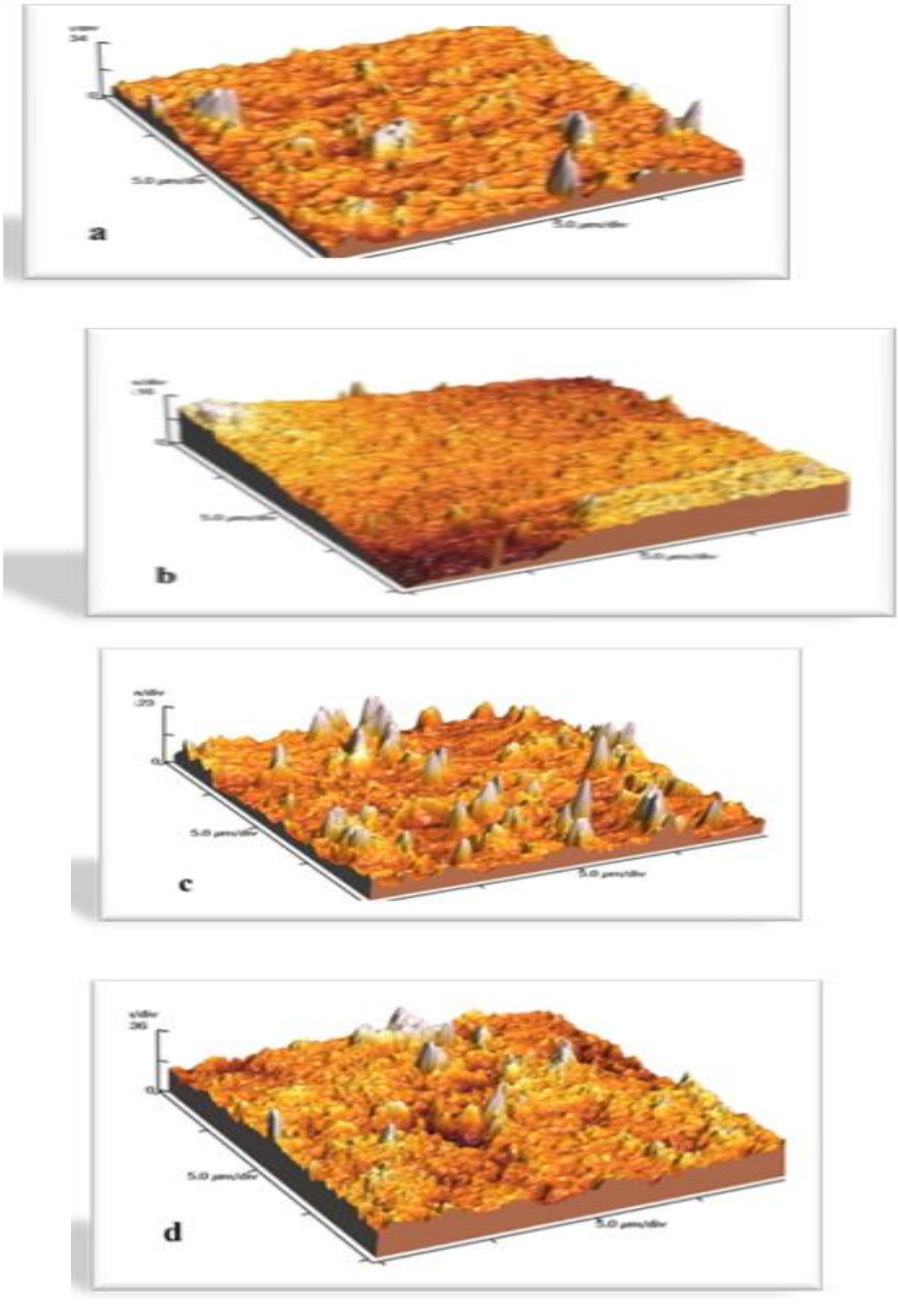

Fig 1: 3D AFM image of Tertic N Ceram composite specimens; a) Mylar strip b) three step system c) one step system d) liquid polisher

IV. Discussion

Surface quality is an important parameter that influences the behavior of dental restorations in the oral environment in different ways. It has been established that it is closely related to both inherent material characteristics such as size, hardness, amount of filler particles and structure of the resin matrix and the polishing procedure.30

The effectiveness of finishing and polishing procedures on esthetic restorative materials is an important step in restorative treatment. In accordance with scientific literatures, smoother surfaces are obtained by curing the materials against the Mylar strips. Unfortunately, the surface obtained by Mylar strips is rich in the organic resin. Therefore, the removal of the outermost resin by finishing and polishing procedures would tend to produce a harder, more wear resistant and hence a more esthetically stable surface. Also even with careful placement of the matrix, removal of excess materials or recontouring of the restoration is often clinically necessary.31

It is mostly necessary to use finishing diamond or carbide burs to contour anatomically structured and concave surfaces. Brackett et al 32 reported that the use of carbide burs for finishing procedures caused a higher degree of leakage than other methods tested. Jung 33 suggested that finishing diamonds were best suited for gross removal and contouring because of their high cutting efficiency of composite surface. Another study by Ferracaneet al 34 also found that finishing diamonds were more efficient in removing material from the composite surface.

Profilometers have been used for many years to measure surface roughness in vitro investigation. They provided limited two dimensional profiles, but an arithmetic average roughness can be calculated and used to represent various material/polishing surface combinations that assist clinicians in their treatment decision.35 Ra is one of the first parameters used to quantify surface texture and it is the most commonly used parameter in dentistry applications. It is the arithmetic average height of the roughness component irregularities from the mean line measured within the sampling length.36 However, the complex structure of a surface cannot be fully characterized by the use of only surface roughness measurements. Therefore, it is not appropriate to draw conclusions on the clinical suitability of a finishing instrument exclusively on the basis of roughness average results. Therefore, in combination of Ra with atomic force microscopy (AFM) evaluation of the destructive potential of the finishing tool, more valid predictions of clinical performance can be made.37

In this study, among polishing systems tested, liquid polisher produced the smoothest surfaces for the restorative material tested, but significantly differed than surfaces created with Mylar strip. These results were confirmed with Saracet al 38 who concluded that glaze appears to fill the structural micro defects and provide a more uniform, regular surface. Surface sealants had the potential to smoothen rough surfaces without previous polishing.

Other studies have already reported that surface sealants could not compensate the surface irregularities from treatments as well as conventional polishing procedures. Therefore, some studies recommend a combination of polishing and sealing. 39,40 Surface sealants would be of interest for covering restorations in anterior teeth, where aesthetics are of high importance. The application of surface sealants would be time saving as compared to multi-step polishing procedures and guarantee a lustrous aspect of the restorations. However, as revealed in this study, surface sealants tend to debond and degrade. Although yearly recoating has been suggested in other studies, 41,42 it seems to be unrealistic to perform.

The multiple-step system evaluated during the present study was more effective in providingsmoother surfaces for tested composite than one step. This fact can be explained by its sequential order of using with abrasiveness decreasing, favoring the final surfacetexture.43

V. Conclusion

Based on the findings of this study, it can conclude that Liquid polisher exhibited the least surface roughness among the tested polishing systems but still worse than mylar strip.

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