RESEARCH PAPER

Influence of Various Polishing Systems on the Surface Roughness of Nanofilled Composite Resin: A Comparative in Vitro Study

Tay Hatem Kadhom

Department of university healthcare, Al-Nahrain university, Iraq

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ABSTRACT

This study aimed to assess and compare the surface roughness of nanofilled resin based composite (Filtek Z-350 XT) after using different finishing-polishing systems. sixty disk shaped samples were made from resin composite by using standardized cylindrical metal mold with measurements of 2 mm in thickness and 10 mm in diameter. The samples were randomly assigned to six experimental groups (number = 10): group 1 (transparent Mylar strip), group 2 (Sof-Lex discs), group 3 (Super-Snap discs), group 4 (OptiDisc discs), group 5 (Opti1Step polishers) and group 6 (OneGloss polishers). For each sample, the mean value of average surface roughness (Ra) was defined after three-times measurements using a profilometer. Depending on the results of ANOVA test, the surface roughness of the evaluated groups was in the following arrangement: transparent strip < Super Snap discs < OptiDisc discs < Opti1Step polishers < SofLex discs < OneGloss polishers. The difference was statistically significant for composite surface roughness in the six study groups (P < 5%). The surface finish of Filtek Z-350 XT nanofilled composite was found to be influenced by the following factors: composition of the finishing-polishing system used, number of polishing steps, in addition to the flexibility of the system during execution of finishing and polishing procedures.

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INTRODUCTION

Smooth surface finish is clinically important, regardless of the location and cavity class, as it sets the longevity and esthetic of resin based composite restorations. A rough surface outcome has a great influence on the esthetic appearance and discoloration of composite restorations, accumulation of dental plaque, irritation of gingiva, secondary caries, and wear of adjacent and opposing surfaces of the teeth [1].

The surface roughness of resin-based composite restorations depends upon numerous factors, including: particles content, size, shape and inter-particle spacing; degree of curing; monomer type and efficient filler-matrix bond. Currently, the surface roughness has significantly been improved by increasing the filler loading and reducing particle size. With regard to the polishing systems, hardness, shape and grit size of the abrasives and flexibility of the matrix, where abrasive components is embedded, perform a critical role [2].

Numerous studies have explained that the best surface smoothness has been produced by multi-steps aluminum oxide finishing and polishing discs. Many attempts have been made to develop one-

* *Corresponding Author Email: tayhatim212@gmail.com*

step finishing-polishing instruments for composite restorative materials. Contouring, finishing and polishing steps can be accomplished with the use of one instrument, and it seems effective as multiple-steps systems for finishing and polishing of resin composites [1].

Evaluation of surface roughness utilizing profilometer has been the standard to measure deterioration of restorations of various dental material types. Ra is defined as the arithmetic mean of vertical departure of a profile from the mean and it is the most commonly used parameter to describe surface roughness [3].

MATERIALS AND METHODS

The nanofilled composite resin tested in this in vitro study was Filtek Z-350 XT. The properties of this restorative material presented in Table 1. Five different polishing systems evaluated: Sof-Lex (SL) discs finishing-polishing system (3M ESPE, MN, USA), SuperSnap (SS) discs finishing-polishing system (Shofu INC, Kyoto, Japan), OptiDisc (OD) discs finishing-polishing system (KerrHawe, Bioggio, Switzerland), Opti1Step (OS) finishing-polishing system (KerrHawe, Bioggio, Switzerland) and OneGloss (OG) finishing-polishing system (Shofu INC, Kyoto, Japan). Table 2 shows properties of the finishing-polishing systems tested.

Specimens Preparation

sixty disk-shaped specimens were made from the composite material by the use of standardized cylindrical metal mold with measurements of 10 mm in diameter and 2 mm in thickness. The cylindrical mold positioned on the transparent mylar strip which was supported by microscopic glass slide (1 mm in thickness). Optrasculpt pad instrument was carefully used to place the material into the mold. The composite resin was covered with another mylar strip on the top surface of the filled metallic mold. After that, another glass slide was positioned on the matrix strip and for a duration of 20 seconds, a constant pressure of (1 kg) was applied to remove excess resin from the mold and creating a specimen of a flat surface. Each side of two-sided sample was light cured for 40 seconds with a led light curing unit emitting no lower than 600 mW/cm2. Light intensity was frequently monitored using a curing light-meter before starting the polymerization. In order to maintain a constant distance of 1 mm between the curing device and the sample, the tip of the curing device was perpendicularly placed in touch with the top aspect of the glass slide. Immediately after polymerization, the cured samples were eliminated from the metallic mold and stored in an incubator with distill water at temperature of 37°C for 24 hours before starting finishing step.

To decrease variability of work, all sample preparations, finishing step and polishing procedures were carried out by the same operator.

Samples Grouping

After the storage period, samples were randomly distributed into six experimental groups (number = 10) as follows: group 1 (transparent Mylar strip), group 2 (Sof-Lex discs), group 3 (Super-Snap discs), group 4 (OptiDisc discs), group 5 (Opti1Step polishers) and group 6 (OneGloss polishers).

Finishing of Samples

Samples in all the experimental groups, except for the Mylar strip group were surfaced with light hand pressure for 15 seconds by using fine diamond burs and high-speed hand-piece under water cooling to clinically mimic the finishing procedure. The finishing step was executed in one direction that was marked on the specimen surface previously. Care was taken to keep parallelism

Table 1. Characteristics of the restorative material evaluated.

Material	Classification	Composition	Particle Content vol (%) wt (%)	Shade	Lot #
Filtek Z350 XT (3M ESPE, MN, USA)	Nanofilled	Resin Matrix: bis-GMA, TEGDMA, UDMA and bis-EMA resins. Fillers: silica fillers (20 nm), zirconia fillers (4-11 nm), and zirconia/silica cluster fillers (average size of 0.6-10 microns) comprised of 20 nm silica and 4-11 nm zirconia filler particles	63.3 78.5	A2E	N774006

Table 2. Details of the experimental polishing groups.

Experimental systems	Content
Sof-Lex (SL) discs (3M ESPE, St. Paul, MN, USA)	Aluminum oxide coated disks: medium grit 30 µm, fine grit 30 µm and superfine grit 3 µm
SuperSnap (SS) discs (Shofu INC., Kyoto, Japan)	Silicon Carbide and Aluminum oxide coated disks: medium grit 30 µm, Fine grit 20 µm and superfine grit 7 µm
OptiDisc (OD) discs (KerrHawe, Bioggio, Switzerland)	Aluminum oxide impregnated discs: Coarse-Medium grit 40 µm, Fine grit 20 µm, Extra-fine grit 10 µm
Opti1Step (OS) finishing-polishing system (KerrHawe, Bioggio, Switzerland)	Diamond particles impregnated polishers
OneGloss (OG) finishing-polishing system (Shofu INC., Kyoto, Japan)	Silicon polishers with integrated aluminum oxide abrasives

during finishing of the samples. The finishing bur was changed after application on five samples.

Specimens Polishing

Polishing procedures of the experimental groups were done following their manufacturer's instructions:

Group 1 (Transparent strip) (Control): Finishing and polishing procedures were not executed after light cuing.

Group 2 (Sof-Lex): Samples initially polished at speed of 10,000 rpm for 20 seconds with medium grit aluminum oxide coated discs, after that, with the fine and superfine discs at speed of 30,000 rpm each for a duration of 20 seconds with dry condition. following each polishing step, samples were completely washed for a duration of 10 seconds with water to eliminate debris, then for a duration of 5 seconds, dried with air, after that polished with the subsequent disc until the final polishing step.

Group 3 (Super-Snap): Specimens were initially polished at 10,000 rpm for 20 seconds with the medium grit silicon carbide coated discs, after that, with the fine and superfine grit disks at 10,000 rpm each for a duration of 20 seconds with dry condition. After completion of each polishing disk, samples were completely washed for 10 seconds with water to eliminate debris, then for 5 seconds, dried with air, after that polished with subsequent disc of lower grit until the final polishing step.

Group 4 (OptiDisc): Samples initially polished for 20 seconds with coarse-medium aluminum oxide coated disks at speed of 10,000 rpm, after that polished with fine and extrafine grit disks each for a duration of 20 seconds at 10,000 rpm with dry condition. Following the use of each polishing disk, samples were thoroughly washed for a duration of 10 seconds with water to eliminate debris, then for 5 seconds, dried with air, after that polished with subsequent disc of lower grit until the final polishing step.

Group 5 (Opti1Step): Disk-shaped diamond abrasives impregnated single step finisher-polisher was used to polish the samples in this group, initially with heavy hand pressure, after that with light hand pressure for a duration of 20 seconds at speed of 10,000 rpm with dry condition. After that, the polished samples were completely washed for 10 seconds with water to eliminate debris, then for 5 seconds dried with air.

Group Six (OneGloss): Disk-shaped aluminum oxide impregnated single step finisher-polisher was used to polish the specimens in this group, initially with heavy hand pressure, after that with light hand pressure for a duration of 20 seconds at speed of 10,000 rpm with dry condition. After that, the polished samples were completely washed for 10 seconds with water to eliminate debris, then for 5 seconds dried with air.

Disc shaped polishers were selected in the present study to gain direct touch and contact with surfaces of the samples. Slow speed hand-piece was employed in one direction that was previously marked on the sample surface. New polishing disk and new finisher-polisher were selected for each specimen. Specimens were positioned with the aid of double sided adhesive tape on a bench vice in order to keep constant position, facilitating execution of the finishing and polishing steps.

Surface roughness measurements and Statistical analysis

After execution of polishing step, the resin composite samples rinsed and dried, after that stored for 24 hours in 100% humid environment before initiating measurements of the material surface roughness. For each specimen, the Ra (average surface roughness) was measured three-times and the mean values of Ra were calculated. Measurements were carried out at the center of each sample with a cut-off value of 0.25 mm and a length of 5 mm using a surface profilometer (TR 200, Germany).

Statistical analysis of the data was accomplished by using SPSS software version 23. Mean and standard deviation of the Ra values were calculated for each experimental group. To define if there is statistical difference among the tested groups, ANOVA and LSD tests were selected. Statistically, P values higher than 5% regarded as non significant, whereas equal to or lower than 5% regarded as significant.

RESULTS AND DISCUSSION

The values of the mean and standard deviation of the material surface roughness µm for all the six evaluated groups were showed in Table 3. The results of ANOVA test showed that among all the tested groups, surface roughness (Ra) of the restorative material was arranged in the following manner: transparent strip (control) < SuperSnap (SS) discs < OptiDisc (OD) discs < Opti1Step polishers < SofLex (SL) discs < OneGloss polishers. The difference was statistically significant for material roughness values in all the six evaluated groups ($P < 0.05$).

The capability of polishing a restorative material is a significant feature that clinically affects the behavior of dental restoration. After execution of finishing and polishing procedures, surface quality of tooth-colored dental restorations was affected by the type, hardness, size, and content of the fillers in these restorative materials, also influenced by the flexibility of the finishing instrument, abrasives hardness, size of grit, and the method of application [4].

In this in vitro study, Mylar strip produced the smoothest surface of the nanofilled composite. The surface gained with a transparent strip ideally smooth and rich in resin organic matrix. So, elimination of the superficial resin by finishing and polishing processes would tend to create a harder and more wear resistant layer, as a consequence an esthetically stable surface. Despite careful matrices placement, elimination of excess materials and re-contouring of dental restorations is often mandatory in clinical situations. This needs some degree of finishing and polishing that will violate the smooth surface acquired with a dental matrix [5].

Numerous studies have explained that the smoothest surface of tooth-colored restorations was obtained by the use of transparent matrix. The current study results were in agreement with those of the previous studies [3-7]. Inconsistent finding to this in vitro study was showed by the study of Sapra et al. [8], which could be related to the reason that baseline roughening of all the samples (including controls) was made in their study, whereas in the present study, mylar strips created surfaces considered as controls without any treatment.

In clinical situations, functional adjustments are mandatory in approximately all dental restorations; therefore, in the present study, the finishing step was made by the use of fine diamond burs to simulate the clinical finishing procedure.

Results of this study showed that Super-Snap and OptiDisc polishing systems created lower roughness values in comparison with Sof-Lex system. These findings are confirmed by the studies of Rai and Gupta [6] and Barbosa et al. [9], who found lower values of surface roughness by

Table 3. The mean values of surface roughness (Ra) **µm** and standard deviation for the experimental groups.

Experimental groups	Number of samples	Mean values	Standard Deviation values
Transparent Mylar strip	10	0.1310	0.01051
Sof-Lex	10	0.3506	0.02100
Super-Snap	10	0.1509	0.01404
OptiDisc	10	0.2054	0.01881
Opti1Step	10	0.2508	0.02365
OneGloss	10	0.6605	0.02278

SuperSnap polishing discs in comparison with Sof-Lex polishing discs proposing a superior capability of SuperSnap system to erase the material scratches produced by the diamond finishing bur. In this context, da Costa et al. [10], showed that SuperSnap produced a smoother surface (not significantly different) from Soft-Lex discs when used on nanofill composite (Filtek Supreme Plus-FS).

The results of the current study disagreed with results of Singh et al. [5], who showed that the samples polished with Sof-Lex disks in planar motion produced lower surface roughness values than the samples polished with rotary motion by using SuperSnap disks in Z-350 (nanofilled) and Z-250 (microhybrid) composites. This could be attributed to differences in the polishing motion employed.

Surface finish created by multi-step polishing systems (SuperSnap and OptiDisc disks) was better than that achieved with One-step finishing-polishing systems (Opti1Step and OneGloss polishers). The results of the current study are in accordance with Lainović et al. [11]. A possible explanation for this fact relies on differences in the composition of these polishing systems, in addition, multi-step polishing systems are more flexible and include more steps with decreasing grit order than one-step polishing systems, which are designed with the idea of finishing and polishing by using the same instrument only by changing the contact pressure. Therefore, multi-step polishing systems causing less dislodgement of filler or resin particles.

Some studies exhibited that more steps (multi-step aluminum oxide discs) involved in the polishing of nanofilled composite resins, the lower the surface roughness is. However, the usage of single step polishing systems is recommended in order to save costs and clinical operative time [8, 12-14].

In the present study, Opti1Step polishing system (diamond abrasive particles) resulted in smoother surfaces than aluminum-oxide Sof-Lex discs polishing system, this might be attributed to the composition and optimized flexibility which enable the polisher to remove scratches on the surfaces of composite resin created by the use of diamond burs during the finishing step and deliver results comparable to multi-step systems and procedures.

In this in-vitro study, Opti1Step system resulted in lower roughness values than OneGloss polishers. Superior performance of Opti1Step polishers might be assigned to the quality of the diamond abrasives embedded in this system, which promote equal surface wear of both hard and soft phases of rein composite producing smooth polished layer with less filler particles protruding from the restoration surface, in addition to that, Opti1Step could be more flexible than OneGloss during finishing-polishing procedures. Performance of the abrasive systems is associated with the flexibility of backing material where the abrasive particles is embedded, abrasive hardness, instrument geometry and its method of use [3, 15].

CONCLUSION

Within the limitations of the present study, surface finish of Filtek Z-350 XT nanofilled composite was found to be influenced by the following factors: composition of the finishing-polishing system used, number of polishing steps, in addition to the flexibility of the system during execution of finishing and polishing procedures.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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