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Comparative evaluation of two different polishing systems on the surface roughness of nano-composite resin materials, an in vitro study.

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Abstract

Context: Highly finished and polished/ smooth surface is somewhat difficult to obtain from composite resin restoration as the resin matrix and the organic filler differ in hardness preventing homogeneous abrasion. Thus, it is important to determine which polishing system will provide the smoothest surface for the different commercially available composites.

Aim: The aim of this in-vitro study is to evaluate and compare two different polishing systems on surface roughness of nano-composite resin materials.

Study setting and design: This was an experimental prospective in-vitro study conducted at dental learning institution.

Methods and materials: Two different composite resins were used in this study; Group I: Nano-filled composite resin (Filtek Z350 XT) Group II: nano-hybrid composite

resin (Filtek Z250 XT). A total number of one hundred and twenty samples were prepared comprising sixty specimens from each type of tested resin composite material fabricated using a circular mould (10mm diameter × 2mm thick). Both groups were further divided into three subgroups, according to polishing system used. Subgroup A – Mylar strip (control, n = 20), Subgroup B - PoGo (n = 20), Subgroup C – Sof-Lex (n = 20). Samples were polished according to the manufacturer's instructions. The average surface roughness (Ra, µm) of all samples were measured using surface profilometer.

Statistical analysis: Data were analysed by using independent sample‘t’ test to compare the means between two groups to evaluate the inter-group and intra-group comparison.

Results: Group I produced smoother surfaces than Group II ($P < 0.05$). Mylar strip and Soflex discs created equally smooth surfaces, while significantly rougher surfaces were obtained after applications of PoGo discs ($P < 0.05$).

Conclusion: Polishing ability of Soflex discs is better than PoGo discs. Nano-filled composite resin renders better polished surface than Nano-hybrid composite resin.

Key words: Composite resin, Nano-filled, nano-hybrid, PoGo, Soflex.

Introduction

The ultimate goal of dental restorative material is to replace the biological, functional and esthetic properties of healthy tooth structure. Composite resins are widely used for the direct/ indirect restoration of both anterior and posterior teeth because of improved aesthetic, physical and mechanical properties & simple bonding procedures.

With the introduction of nano-technology to the dental profession, a new class of composite resins- Nano-composites have been developed in recent years. Nano-composites are claimed to combine the mechanical strength of hybrid resin composites and the superior aesthetic properties of micro-filled materials.[1] The surface texture of tooth coloured restoration has a major impact on the aesthetic appearance of the restoration, discoloration, plaque accumulation,[2,3] gingival irritation, abrasion and wear kinetics. [4,5] Both aesthetics and longevity of composite restorations strongly depend on quality of finishing and polishing.[6,7] But a highly finished and polished surface of composite resin restoration is somewhat difficult to obtain as the resin matrix and the organic filler differ in hardness preventing homogeneous abrasion.[8]

Thus, it is important to determine which polishing system will provide the smoothest surface for the different commercially available composites. Various polishing techniques have been introduced in market. They are generally discussed under two terms: multi-step systems and one-step systems. “Multi-step” systems contain series of discs. Ex. Sof-lex discs. Manufacturers introduced the “one-step” polishing systems, where single instrument is used for finishing and polishing procedures. Ex. PoGo discs [9]

Literature fails to show the difference in the efficacy of Sof-Lex discs & PoGo discs. So, the aim of this in-vitro study is comparative evaluation of these two different polishing systems on surface roughness of commonly used nano-composite resin materials.

Materials and methodology

One hundred and twenty sample discs of two nano-composites were prepared to measure the surface roughness using profilometer.

- Group I - Nanofilled composite resin: Filtek Z350 XT (3M ESPE, MN, USA)
- Group II - Nanohybrid composite resin: Filtek Z250 XT (3M ESPE, MN, USA)

Samples were prepared in the form of discs using a circular mould of transparent plexiglass having diameter of 10mm and thickness of 2mm. The mould was placed on

a transparent mylar strip supported by a glass slide from below and it was overfilled with composite resin material with the help of restorative instruments. The mould and composite resin was covered by another matrix strip and glass slide. Light pressure was applied until the upper matrix strip and slide came into contact with the mould to expel excess composite material and to avoid air entrapment. Each specimen was polymerized through the top of the glass using a high intensity source of blue light source (Elipar, 3M St. Paul, MN, USA) for 20 seconds, according to the manufacturer's instructions. Then, the specimens were stored in 100% humidity at 37 0C for 24 hours. In order to control variability, all specimen preparation and further polishing procedures were performed by the same operator.

Each group was further divided into three subgroups containing twenty specimens each. According to different polishing techniques the subgroups were:
Subgroup A - Control (n=20)

Subgroup B - Specimens were polished using one-step polishing system: PoGo discs (Dentsply Caulk, Milford, USA) (n=20)

Subgroup C- Specimens were polished using multi-step polishing system: Sof-lex discs (3M ESPE, MN, USA) (n=20)

Twenty samples from each group left untreated, as control (Mylar strip). Remaining forty samples were wet ground with 1200 grit silicon carbide sand paper for one minute to provide a base line and to remove resin rich superficial layer before using the polishing systems. For polishing a slow-speed hand piece rotating at a maximum 15,000 rpm was used with a constant light hand pressure using a planner motion. A new polishing disc was used for each specimen and was discarded after each use. Each sample was subjected to polishing procedure according to the manufacturer's instructions. After polishing procedure, all samples were washed. Readings were taken using surface profilometer (Zeiss SURFCOM 130A, USA); 4 times in different directions from the centre of the specimen. Measurement length was 0.25 mm in each direction, giving a total evaluation of 1 mm. The average surface roughness (Ra, µm) including the control were noted down.

The analysis was carried out with SPSS software version 13 (IBM SPSS Statistics, USA) Independent Sample't' test was used to compare the means between two groups to evaluate the inter-group and intra-group comparison. A P-value of 0.05 or less was considered as statistical significance.

Results

According to Table 1, mean surface roughness for nano-filled composite resin in Group I-A is 0.026 µm, in Group I-B is 0.259 µm and in Group I-C is 0.185 µm. Therefore, results of surface roughness after polishing for nano-filled composite resin can be summarized as follows: Control (Mylar strip) < Multi-step polishing system (Soflex) < One-step polishing system (PoGo). Mean surface roughness for nano-hybrid composite resin in Group II-A is 0.033 µm, in Group II-B is 0.378 µm and in Group II-C is 0.253 µm. Therefore, results of surface roughness after polishing for nano-hybrid composite resin can be summarized as follows: Control (Mylar strip) < Multi-step polishing system (Soflex) < One-step polishing system (PoGo). It was also revealed that best surface smoothness was obtained by Mylar strip.

Nano-filled composite resin showed least surface roughness in all experimental groups than nano-hybrid resin. The difference is statistically significant as shown in Table 2.

Table l: Groups after using different polishing systems.

Group	Polishing System	Mean	N	SD	t	Df	P value
I. Nano-filled Composite Resin	PoGo discs	0.259	20	0.04176	24.82	38	< 0.001*
	Control	0.026	20	0.00412			
	Soflex discs	0.185	20	0.02016	34.44	38	< 0.001*
	Control	0.026	20	0.00412			
	PoGo discs	0.259	20	0.04176	7.18	38	< 0.001*
	Soflex discs	0.185	20	0.02016			
II. Nano-hybrid Composite Resin	PoGo discs	0.378	20	0.10233	14.00	38	< 0.001*
	Control	0.033	20	0.00742			
	Soflex discs	0.253	20	0.02486	37.80	38	< 0.001*
	Control	0.033	20	0.00742			
	PoGo discs	0.378	20	0.10233	4.32	38	< 0.001*
	Soflex discs	0.253	20	0.02486			

* indicates that P value is Highly Significant

Table 2: Comparison of surface roughness between nanofilled and nanohybrid composite resin after use of one-step PoGo discs & Multi-step Soflex discs

Polishing System	Composite Resin	N	Mean	SD	t	df	P value
One-step PoGo discs	Nanofilled	20	0.259	0.04176	-3.85	38	< 0.001*
	Nanohybrid	20	0.378	0.10233			
Multi-step Soflex discs	Nanofilled	20	0.185	0.02016	-9.49	38	< 0.001*
	Nanohybrid	20	0.253	0.02486			

* indicates that P value is Highly Significant

Discussion

Nanotechnology has led to the development of new composite resins which can be used in anterior as well as posterior regions in the oral cavity.[10] Nano composites contain filler particles with sizes less than 10 nm (0.01 μm) and are claimed to provide increased aesthetics, strength and durability. Composites are finished and polished in order to establish a functional, occlusal relationship and a contour physiologically in harmony with supporting tissues. In addition, proper contour and high gloss prevents plaque accumulation, discoloration & give the restoration the appearance of natural tooth structure.

According to study carried out by Stoddard and Johnson, the effectiveness of finishing/polishing system depends on type of composite (filler size and content), type of abrasive used, time spent with each abrasives, strokes, amount of pressure applied, orientation of abrading surfaces and geometry (discs, cups, cones) of abrasive instruments.[11]

Fruits and others[12] explained three types of motions for optimal surface smoothness: A rotary motion (circular), a planar motion and a reciprocating motion. In the current study, a planar motion, which is a rotational movement with the axis of rotation of the abrasive device perpendicular to the surface being smoothed (abrasive discs), was used for all polishing systems. In order to have uniform contact with flat sample surfaces, instead of cups & cones; disc shaped polishing systems were used. In this study, two polishing systems were used, viz. one-step polishing system i.e. PoGo and multistep polishing system i.e. Sof-lex.

Surface roughness can be measured up to nanoscale by qualitative methods, such as scanning electron microscopy (SEM), or quantitative methods, such as profilometry. Surface profilometer is one among many techniques to measure surface roughness.[13] Since quantitative measurement is possible, easily available tool and inexpensive so the profilometer was used to determine surface roughness.[14] In this study, the surface roughness was measured in four different directions 0.25mm from the centre; making multidirectional total measurement of 1mm length.

The results of this study showed that both control groups i.e. Group I-A and Group II-A showed least surface roughness within their respected groups. Among both the experimental groups the use of multi-step polishing system (Sof-lex discs) had less mean surface roughness as compared to mean surface roughness due to use of one-step polishing system (PoGo discs) and this difference was statistically significant. Observations of surface roughness can be summarized as follows:

Control (Mylar strip) < Multi-step (Soflex) < One-step (PoGo) polishing system.

The control group showed maximum surface smoothness due to presence of resin (organic matrix) rich layer on the surface[15] which need to be removed by finishing & polishing to avoid discolouration[16] and accelerated clinical wear[17].

The results of this study are in accordance with the study conducted by Barbosa et al[15] and Schmitt et al[18]. The aluminium oxide impregnated multi-step Sof-lex discs are more flexible due to polyester film than diamond coated one-step polishing disc. Sof-lex discs produces better surface smoothness by homogeneous abrasion of filler particles and matrix equally.[19] Studies have shown non-displacement of composite filler particles by multi-step disc.[15,18] The multi-step sof-lex discs are available in course, medium, fine and superfine grit. Each sequential disc with a finer grit removes imperfections caused by a former disc, creating a smooth and shiny surface.[4]

One step PoGo abrasives provided rougher surface finish than Sof-Lex discs. This could be attributed to the fact that diamond (PoGo) discs are made up of urethane dimethacrylate resin & are less flexible as compared to the flexible polyester Sof-Lex discs.[20]

In this study, the nanofilled composite resin showed less mean surface roughness as compared to nanohybrid composite resin, after using both the polishing systems. The difference was highly statistically significant. The probable reason may be inclusion nano-sized filler particles, called nanomers and agglomerations of these particles described as “nanoclusters” in nanofilled composite.[21] The nanoclusters provide a distinct reinforcing mechanism compared to nanohybrid systems

resulting in significant mechanical properties. Whereas nanohybrid types contains milled glass fillers and discrete nanoparticles (40–50 nm).[22] Studies revealed that finer filler particle size in nano-filled composite results in less inter-particle spacing, more protection of softer resin matrix and less filler pulling all of which lead to enhanced wear resistance of the material.[23]

Limitations of the study

There are some limitations in this study such as the flat surface of the sample (a condition that does not exist clinically) and also the study was performed in-vitro, so the effect of the oral environment was neglected. These limitation can be improved by preparing the sample in the tooth itself to follow the tooth morphology. Also in-vivo studies are required to investigate the possible effect of oral environment on the surface roughness of such restorations.

Conclusion

Based on the appraisal of results and keeping in mind the limitations of the study, to evaluate the effect of two different polishing systems on the surface roughness of nano composite materials, it can be concluded that:

- Sof-lex multi-step polishing system is more efficient than PoGo one-step polishing system.
- Nano-filled composite resin showed minimum surface roughness for all the polishing systems tested followed by nano-hybrid composite resin.

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