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Effect of Different Finishing & Polishing Systems on the Surface Roughness of Composite Resins: An In Vitro Study

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ABSTRACT

Background: Increasing environmental concerns and public demands for tooth coloured materials have heralded patients to demand the replacement of traditional metallic restorations by more esthetic & biocompatible materials. Search for an ideal esthetic material for restoring teeth has resulted significant improvement in both esthetic material and technique for using them.Composite resins have become the material of choice in both the anterior and posterior restorations considering the esthetics. However, among some of the problems associated with using resin composite restorations is surface roughness. Finishing and polishing procedures are essential to avoiding secondary caries, periodontal integrity, marginal integrity and wear reduction and contribute to longevity of the restoration by preventing the plaque accumulation on the surface of the restoration.Various improved finishing and polishing systems are available in market for the same purpose. But as an astute clinician one needs to evaluate the various polishing systems available to conclude their efficiency and results. The present study evaluates the efficiency three different finishing and polishing systems for composite resins.

Keywords: Evidence, Implantology, Periodontal disease.

INTRODUCTION

It is a challenge for every aesthetic dentist to determine and replicate the appearance of teeth to mimic nature to its closest sense and form.. The continuous development of aesthetically acceptable adhesive restorative material has made a variety of tooth colored materials available for clinical use[2]. On the extreme ends of the continuum of direct tooth-colored restorative materials are conventional glass ionomer cements (GICs) and the resin composite[1]. The advent of visible light polymerizing resin and the use of finer filler particles permit resin composites to be polished to higher degree. Many researchers agree that regardless of the type of resin composite used, the smoothest surface imparted to resin composites occurs when they have been allowed to set against a Mylar strip and that any subsequent finishing and polishing procedures are detrimental to the surface of the composite restoration[3,4]. But the matrix finished surfaces are polymer-rich and relatively unstable; hence this requires some degree of finishing and polishing[1]. Therefore, the esthetic value of a composite restoration is dependent on

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the finishing and polishing of the surface of the restoration.

Finishing is the gross contouring of a restoration to obtain desired anatomy, while polishing refers to reduction of roughness and removal of scratches created by the finishing instrument[4,5]. A variety of instruments are commonly used for finishing and polishing tooth-colored restorative materials including: carbide finishing burs, diamond finishing burs, abrasive impregnated rubber cups and points, aluminum oxide coated abrasive discs, abrasive strips, and polishing pastes. Each of these instruments or devices leaves the surface of various restorative materials with varying degrees of surface roughness[6,7] . A smooth surface has always been the prime objective of composite restorations not only for esthetic consideration but also for oral health[6].The marginal finish of a restoration, surface roughness, and surface integrity as well as the physicochemical properties of the material itself can affect plaque retention. Threshold surface roughness for bacterial retention is 0.2µm, below which no further reduction in bacterial accumulation could be expected. An increase in surface roughness above this threshold roughness however resulted in a simultaneous increase in plaque accumulation, thereby increasing the risk of both caries and periodontal inflammation[7,8]. Therefore, maintaining the smooth surface of a restoration is of utmost importance for its success. In recent years, efforts have been made to analyze the suitability of numerous systems available for the finishing and polishing of various composites. The effect of polishing systems on surface finish has been reported to be material dependent, and the effectiveness of these systems was mostly product dependent. To date, a paucity of information is available on how to finish and polish these novel nano structured resin composites[8,9,10]. Hence, the purpose of this study was to evaluate the efficiency of finishing and polishing systems on the surface roughness of various newer nanofilled composite restorative materials available in the market.

AIMS

1. The aim of the study is to evaluate efficacy of three different polishing systems on Nano composite resins.

2. To evaluate the polishability of different Nano composite resins.

OBJECTIVES

1. To evaluate the efficiency of finishing and polishing systems on the surface roughness of various nanofilled composite restorative materials.

2. To evaluate and compare the surface roughness of nanofilled composite restorative materials polished using three different polishing systems.

MATERIAL AND METHODOLOGY

This study was conducted in the Department of Conservative Dentistry and Endodontics, Goenka Research Institute of dental science, gandhinagar, gujarat. Three Nano filled Composite resins Tetric N Ceram,Ceram X Duo and 3M Filtek Z 350 was used for present study to evalute finishing and polishing with different systems namely as Enhance, Shofu and Sof-lex. The Sof-Lex finishing and polishing discs are made from a urethane coated paper that gives the discs their flexibility. The system comprises of four individual aluminum oxide grits ranging from coarse to superfine. The discs are available in three sizes with a small round eyelet which gets attached to the mandrel. The shofu polishing system combines abrasives in several different shapes such as disks, cups, and points which are pre mounted Dura green,dura white impregnated abrasives along with cured urethane dimethacrylate resin finishers. The Enhance polishing system combines abrasives in several different shapes such as disks, cups, and points which are pre mounted single use aluminum oxide impregnated abrasives along with cured urethane dimethacrylate resin finishers.

Accessories used

Mylar stip	SMITH COMPANY, India
Slow speed hand piece	15,000 rpm speed NSK Japan
Fine finish diamond bur	50µm S.S WHITE U.S.A.
Glass mould	For Fabrication of specimens (10 mm ×4mm)
Light cure	Blue phase (Ivoclar vivadent U.S.A.)

3. Preparation and grouping of the specimens for evaluating surface finish

The tooth colored restorative materials selected for this study includes three nanocomposite materials; Tetric N Ceram (TNC), Filtek Z350 (FZ), Ceram X Duo (CX). The 30 specimens of each composite material were fabricated in the round disc (10mm×4mm) of a customized glass mould and covered with Mylar strips (Total 120 specimens). A glass slide was placed on the moulds and pressure applied to extrude the excess material. The nanocomposite materials were then polymerized using light curing unit which was held at a distance of 1 cm from the specimen . The tip diameter of the light curing unit was 10 mm in diameter. The surface of all the specimens were gross finished with fine finishing diamond bur of 50μm with slow speed handpiece at 15,000 rpm to obtain standardized surfaces. The 40 fabricated specimens of each of the three nanocomposite materials was randomly divided into three groups containing 10 specimens each which was then subjected to polishing by Sof-Lex,shofu and Enhance polishing systems respectively after 24 hours & in control group there were 10 specimens of each composite where no polishing was done.

Sampling method: - The 120 specimens were randomly divided as follows:

Polishing systems	Nanofilled composite resin materials
Group-1 Sof-lex (Total 30 specimens)	Subgroup-A TNC 10 specimens Subgroup-B CX 10 specimens Subgroup-C FZ 10 specimens
Group-2 Shofu (Total 30 specimens)	Subgroup-A TNC 10 specimens Subgroup-B CX 10 specimens Subgroup-C FZ 10 specimens
Group-3 Enhance (Total 30 specimens)	Subgroup-A TNC 10 specimens Subgroup-B CX 10 specimens Subgroup-C FZ 10 specimens
Group-4 control group(Total 30 specimens)	Subgroup-A TNC 10 specimens Subgroup-B CX 10 specimens Subgroup-C FZ 10 specimens

Group -1 (Subgroup A,B,C)- All specimens in this group were subjected to Sof-lex polishing systems.
Group- 2 (Subgroup A,B,C)- All specimens in this group were subjected to Shofu polishing systems.
Group- 3 (Subgroup A,B,C)- All specimens in this group were subjected to Enhance polishing systems.
Group- 4 (Subgroup A,B,C)- All specimens in this group were not subjected to polishing with any systems.

Slow speed hand piece was used for all the polishing systems. The handpiece was used with a constantly moving repetitive stroking action to prevent heat buildup and formation of grooves. There was a conscious effort to standardize the stroke, downward force, and polishing time for all the instruments used. Polishing was done as per manufacturer's instructions.

Profiling procedure: The polished composite resin specimens were washed, allowed to dry and kept in 100% humidity for 24 hours before measuring the average surface roughness values using a mechanical digital Profilometer (Mitutoyo SJ-400 U.S.A). This device essentially consists of a stylus attached to a long lever arm, which is traced along the surface and records the up- and -down movement of the stylus.

It also allows the quantification of the surface roughness by calculating average surface roughness (Ra) values, which is the arithmetic average height of the roughness component irregularities from the mean line measured within the sampling length. The higher this value, the rougher the surface. Three profilometric measurements were accomplished on each specimen and then averaged to obtain the surface roughness of that specimen. The results were analyzed by calculating the mean and standard deviations for each group. The data for each material were subjected to ANOVA and Tukey's HSD test at a P-value of 0.05.

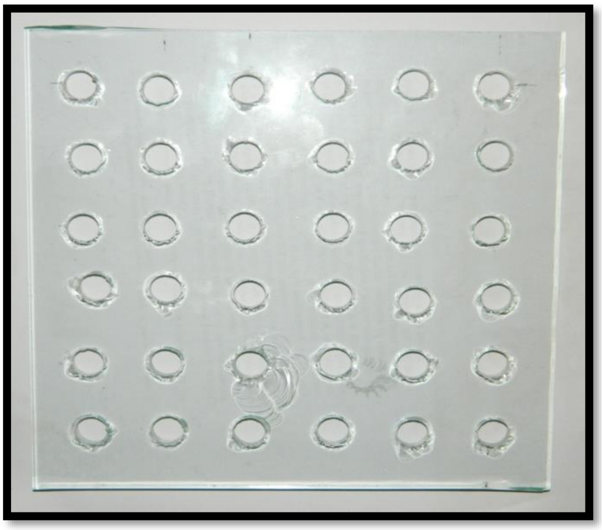


Fig 1: Glass Mould.

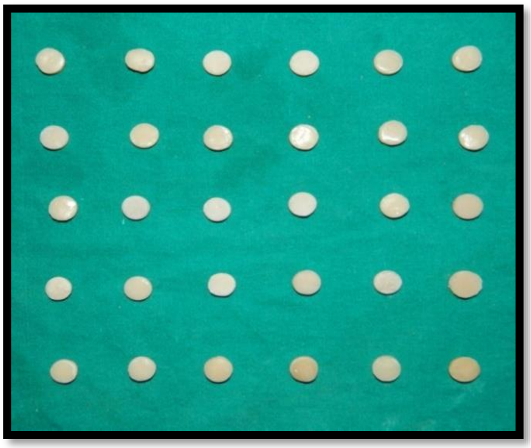


Fig 3: Specimens of Composites.

Fig 2: Blue Phase Light Cure Gun.

Fig 4: Profilometer to Check RA Value of Each Specimen.

Table 1: Comparision of mean surface roughness and standard deviation when composite specimens were not subjected to any polishing system.

Control group	N	Mean	Std.Dev.	Std.Error.
Tetric N Ceram	10	4.7210	0.31346	0.09912
Ceram X Duo	10	6.3320	0.40513	0.12811
3M Filtek Z350	10	3.7210	0.32275	0.10206

Table 2: comparision of mean surface roughness and standard deviation when composite specimens were subjected to enhance polishing system.

Enhance	N	Mean	Std.Dev.	Std.Error.
Tetric N Ceram	10	0.8640	0.06096	0.12811
Ceram X Duo	10	1.0420	0.10633	0.3363
3M Filtek Z350	10	0.7580	0.03521	0.01114

Table 3: Comparison of mean surface roughness and standard deviation when composite specimens were subjected to shofu polishing system.

Shofu	N	Mean	Std.Dev.	Std.Error.
Tetric N Ceram	10	0.7210	0.5238	0.1656
Ceram X Duo	10	0.8060	0.4402	0.1392
3M Filtek Z350	10	0.6360	0.05661	0.0179

Table 4: Comparision of mean surface roughness and standard deviation when composite specimens were subjected to sof-lex polishing system.

Soflex	N	Mean	Std.Dev.	Std.Error.
Tetric N Ceram	10	0.6010	0.06903	0.02183
Ceram X Duo	10	0.7070	0.04572	0.01446
3M Filtek Z350	10	0.4900	0.06616	0.02092

Table 5: Anova to determine statistical significance of difference of mean of each group.

		Sum of Squares	Df	Mean Square	F	Sig.
Tetric-N-Cream	Between Groups	119.887	3	39.962	1460.095	.000
	Within Groups	.985	36	.027		
	Total	120.872	39			
CERAM-X-DUO	Between Groups	225.848	3	75.283	1677.949	.000
	Within Groups	1.615	36	.045		
	Total	227.463	39			
3M FILTEK Z-350	Between Groups	72.110	3	24.037	850.947	.000
	Within Groups	1.017	36	.028		
	Total	73.127	39			

One-Way ANOVA showed that there was very high statistically significant difference in the mean surface roughness among the restorative materials, when they were subjected to Enhance, Shofu and Sof-lex polishing systems.

Table 6a: Intergroup comparison done using tukey's hsd test between the groups of tetric n ceram composite which were subjected to all the three polishing systems

Dependent Variable	(I)	(J)	Mean Difference (I-J)	Std. Error	Sig.
Tetric-N-Cream	Control	ENHANCE	3.85700*	.07399	.000
		SHOFU	4.00000*	.07399	.000
		SOFLEX	4.12000*	.07399	.000
	ENHANCE	Control	-3.85700*	.07399	.000
		SHOFU	.14300	.07399	.233

		SOFLEX	.26300*	.07399	.006
	SHOFU	Control	-4.00000*	.07399	.000
		ENHANCE	-.14300	.07399	.233
		SOFLEX	.12000	.07399	.379
	SOFLEX	Control	-4.12000*	.07399	.000
		ENHANCE	-.26300*	.07399	.006
		SHOFU	-.12000	.07399	.379

Tukey's HSD test in the Tetric N Ceram group:-

A) Control group showed statistically significance difference with other groups-which means control group had more surface roughness compared to other polishing systems.

B) When(Enhance & Shofu)was compared there was no statistically significant difference,which means both the groups performed uniformly in reducing surface roughness.

C) When Enhance and sof-lex was compared there was statistically significant difference indicating that sof-lex performed better in polishing then enhance.

D) When shofu and sof-lex was compared there was statistically no significant difference indicating that both of them performed equally.

Table 6b: Intergroup comparison done using tukey's hsd test between the groups of ceram x duo composite which were subjected to all the three polishing systems.

Dependent Variable	(I)	(J)	Mean Difference (I-J)	Std. Error	Sig.
CERAM-X-DUO	Control	ENHANCE	5.29000*	.09473	.000
		SHOFU	5.52600*	.09473	.000
		SOFLEX	5.62500*	.09473	.000
	ENHANCE	Control	-5.29000*	.09473	.000
		SHOFU	.23600	.09473	.078
		SOFLEX	.33500*	.09473	.006
	SHOFU	Control	-5.52600*	.09473	.000
		ENHANCE	-.23600	.09473	.078
		SOFLEX	.09900	.09473	.724
	SOFLEX	Control	-5.62500*	.09473	.000
		ENHANCE	-.33500*	.09473	.006
		SHOFU	-.09900	.09473	.724

Tukey's HSD test in the Ceram X DUO group:-

A) Control group showed statistically significance difference with other groups-which means control group had more surface roughness compared to other polishing systems.

B) When(Enhance & Shofu)was compared there was no statistically significant difference,which means both the groups performed uniformly in reducing surface roughness.

C) When Enhance and sof-lex was compared there was statistically significant difference indicating that sof-lex performed better in polishing then enhance.

D) When shofu and sof-lex was compared there was statistically no significant difference indicating that both of them performed equally.

Table 6c: intergroup comparison done using tukey's hsd test between the groups of 3m filtek z-350 composite which were subjected to all the three polishing systems.

Dependent Variable	(I)	(J)	Mean Difference (I-J)	Std. Error	Sig.
3M FILTEK Z-350	Control	ENHANCE	2.96300*	.07516	.000
		SHOFU	3.08500*	.07516	.000
		SOFLEX	3.23100*	.07516	.000
	ENHANCE	Control	-2.96300*	.07516	.000
		SHOFU	.12200	.07516	.379
		SOFLEX	.26800*	.07516	.006
	SHOFU	Control	-3.08500*	.07516	.000
		ENHANCE	-.12200	.07516	.379
		SOFLEX	.14600	.07516	.229
	SOFLEX	Control	-3.23100*	.07516	.000
		ENHANCE	-.26800*	.07516	.006
		SHOFU	-.14600	.07516	.229

Tukey's HSD test in the 3M FILTEK Z 350 group:-

A) Control group showed statistically significance difference with other groups-which means control group had more surface roughness compared to other polishing systems.

B) When(Enhance & Shofu)was compared there was no statistically significant difference,which means both the groups performed uniformly in reducing surface roughness.

C) When Enhance and sof-lex was compared there was statistically significant difference indicating that sof-lex performed better in polishing then enhance.

D) When shofu and sof-lex was compared there was statistically no significant difference indicating that both of them performed equally.

Fig 1: Bar graph shows comparion of mean surface roughness when tetric n ceram composite specimens were subjected to polishing systems.

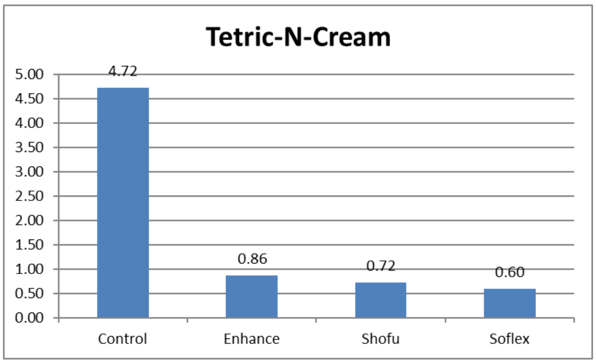


Fig 2: Bar graph shows comparion of mean surface roughness when ceram x duo composite specimens were subjected to polishing systems.

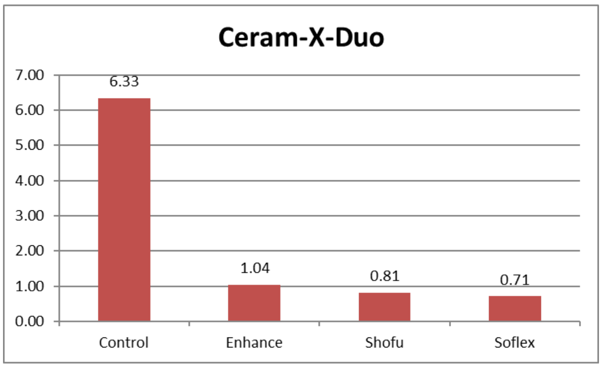


Fig 3: Bar graph shows comparion of mean surface roughness when 3m filtek z 350 composite specimens were subjected to polishing systems.

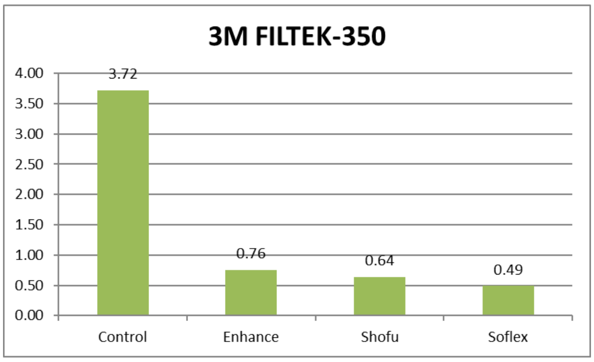
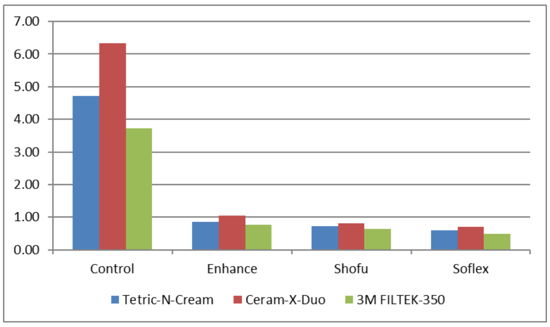


Fig 4: Bar graph shows comparion of mean surface roughness when tetric n ceram,ceram x duo,3m filtek z 350 composite specimens were subjected to polishing systems.



DISCUSSION

The surface micro morphology of resin composites after finishing and polishing has been shown to be influenced by the size, hardness and amount of filler particles. Harder filler particles are left protruding from the surface during polishing, as the softer resin matrix is preferentially removed in hybrid composites. Filler particles should be situated as close together as possible in order to protect the resin matrix from abrasives. Hence, the application of nanotechnology to development of newer resin has great potential. Reduced dimension of the particles with wider distribution can achieve increased filler loading, which results in reduced polymerization shrinkage and improved mechanical properties[8].

The appearance of the restoration is also affected by the degree of surface gloss after polishing and is based on the reflected light from the restoration. The incident light is reflected from the surface of the restoration, which is composed of numerous minute flat surfaces. With the increased surface roughness, the degree of random light reflection increases resulting in decreased gloss. Smooth and glossy surface is the final objective of any polishing procedure. In clinical situations the resin composites are usually polished and exposed to the oral environment immediately after the restoration. Maintaining the surface texture is critical to the esthetics of the restoration.

Although many studies have been done to evaluate the effect of polishing materials on microfilled and hybrid composite materials there is limited information about the polishability obtained when nanofilled composite materials was used. The various nano filled composites used in this study have higher filler loading compared to conventional resin composites. Filtek Z350 contains zirconia-silica particles 5-20nm fillers and 0.6-1.4µm nanoclusters. Ceram X Duo comprises of organically modified ceramic nanoparticles and nanofillers that are combined with conventional glass fillers of approximately 1µm. Tetric N Ceram composite also comprise some features of nanotechnology; hence they are also referred to as nanohybrids[8].

In our study among the nanofilled composite materials tested, Filtek Z350 showed superior polishability than the other composite materials for all three polishing systems. This may be due to the fact that it contains both nanoflllers and nanoclusters and is considered to be a true "Nanofill" composite[2]. A nanocluster filler particle consists of loosely bound agglomerates of nano-sized filler particles. During polishing only the nano-sized filler particles are worn away whereas nanoclusters are not plucked out from the resin matrix. Eventually the surface has smaller defects and better polish retention. Unlike Filtek Z350, Ceram X Duo contains large glass filler particles (l-1.5um) which can be plucked away, leaving voids or rougher surface after being polished. Tetric N Ceram and Cearm X duo composite showed the roughest surface with all three polishing systems. This may be due to the fact that the material contains only a small quantity of inorganic nanoparticles; instead nanoadditives known as rheological modifiers have been incorporated in a targeted fashion. Thus in our study Filtek Z350 gave better polishablity followed by Tetric N Ceram , Ceram X duo composite respectively, which is in accordance with the results of a study done by Ergucu et al in 2007[8].

Several efforts have been made to analyze the suitability of numerous systems available for finishing and polishing. Previously, specially designed diamonds with very fine abrasive particle size and white Arkansas stones was used to polish resin composite restorations[3]. However, its disadvantage of causing rougher surface has led to the introduction of multi-step polishing technique with use of progressively finer grits. More recently One-Step polishing instruments have been available with an aim of achieving same type of polishing as multi-step polishing system. According to Turkun et al and Watanabe et al, polishabilty obtained by multi-step polishing system was superior to that of One-Step polishing systems. Hence in this study multi-step polishing systems were selected to polish these nanostructured composite resin material[2,11].

The efficiency of abrasive systems is related to the flexibility of the backing material in which the abrasive is embedded, hardness of the abrasive, geometry of the instrument and how the instruments are used. For a composite finishing system to be effective, the abrasives must be relatively harder than the filler materials. If not, the polishing agent will only remove the softer resin matrix and leaves the filler particles protruding from the surface[8,]. A rotary motion (circular), a planar motion and a reciprocating motion can be employed to polish the surface of resin composite. In rotary (diamonds and cylindrical stones); the axis of rotation of the abrasive device is parallel to the surface being smoothened. The planar motion is a rotational movement with axis of rotation of the abrasive device perpendicular to the surface being smoothened (abrasive discs)[3]. The reciprocating motion is employed when a finishing strip is pulled back and forth over the surface. The results obtained by Fruits and others (1996) comparing different polishing motions on restorative materials showed that for all possible combination of materials and abrasive grits, the planar motion achieved the lowest average roughness values[2]. In this study, three polishing systems were tested using a planar motion.

The specimens were finished after 24 hours in this study. This is in accordance with the study done by Yalcin et al and Lopes et al who suggested that final finishing should always be delayed for at least 24 hours when composites are used. If finishing is conducted immediately after composite placement, the material might be more readily subject to plastic deformation due to the heat generated during the finishing/polishing procedure. Approximately 75% of light-polymerization occurs during the first ten minutes. The polymerization reaction continues for a 24-hour period if the restoration is immersed in water before finishing procedures[4].

Many studies on the polishing of resin composite have been introduced, and the most commonly used parameter to describe surface roughness is Ra. Surface roughness is a function of the microstructure created by the series of physical process used to modify the surface and is related to the scale of the measurement & Profilometer has been used for years to measure surface roughness for in-vitro investigations. They provide limited two-dimensional information but an arithmetic average roughness can be calculated and used to present various material /polishing surface combination that assist clinicians in their treatment decisions[2,].

In this study Sof-Lex polishing discs produced smoother surface as compared to Shofu and Enhance polishing system *this may* be due to the fact that aluminum oxide disks appear to finish or tend to sand the surface material without dislodging the glass particles. Malleability of Sof-Lex aluminum oxide disks also promotes a homogeneous abrasion of filler and resin matrix. The polishing cups in the Enhance polishing system seemed to cause displacement of filler particles and also grind into the surface causing rougher surface.

This result is in accordance with the study done by Setcos et al, Tate et al, Barbosa et al and Kaplan et al[13,10,7,11] But the results were in contrast with the study done by Marigo et al[6] in which Enhance polishing system gave a better finish for hybrid and microfilled composite as compared to Sof-Lex polishing system. The variation in the result is due to use of nanofilled composite resins in the present study. According to the authors large particles embedded in Sof-Lex disks tend to rip through the surface of the composites and when used with certain hybrid composites tends to cut and abrade filler particles and resin matrix equally, resulting in smoother surface[6].

The results of this current study gave higher Ra values for enhance polishing system compared to shofu polishing system. These result differ from the study by Watanabe et al[2] which showed that shofu polishing system produced a rougher surface when compared to enhance polishing system. The reason for this difference is because they compared microfilled and hybrids composite resins where as we have compared nanofilled composite resins.

CONCLUSION

Within the limitations of this present study, the following conclusions can be drawn:

- All three polishing systems which were used in this study were effective in polishing nanofilled composites. The surface roughness values (Ra) were within acceptable ranges for all the three systems and all the three composites.
- Sof-lex which is a disc-based polishing system showed the best polishing efficiency with the smallest Ra values. This was followed by Shofu polishing kit and lastly by Enhance polishing system.
- Filtek Z 350 exhibited the best polishability followed by Tetric n Ceram; & Ceram X duo showed the least polishability.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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