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COMPARATIVE EVALUATION OF SURFACE ROUGHNESS OF DIFFERENT NANOFILL COMPOSITES POLISHED USING TWO DIFFERENT POLISHING SYSTEMS- AN IN VITRO STUDY

Endodontics

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ABSTRACT

Aim- To comparatively evaluate the surface roughness of different nanofill composites polished using two different polishing systems. **Materials and Methods-** A total of sixty specimen discs (8mm x 2mm) were fabricated using three different nanofill composites (20 each). Group 1 (n=20), FiltekZ350 XT, Group 2 (n=20), Palfique LX5, Group 3 (n=20), Neospectra respectively. 10 specimens from each group were further divided into 2 sub groups depending on the polishing systems used namely, A.S.A.P (All Surface Access Polisher) and Diashine. Surface roughness was evaluated using an optical profilometer. **Results-**Group I Filtek Z350 XT showed statistically significant difference in decreased surface roughness from other tested groups. Among different sub groups it was found that ASAP gave better results than Diashine ie. Group 1A > Group 2A> Group 3A> Group 1B> Group 2B> Group 3B. **Conclusion-** Within the limitations of this study, it can be concluded that Filtek Z350 XT composite gave better results followed by Neospectra and then Palfique LX5 composite when polished with ASAP and Diashine polishing system. Between the two polishing systems ASAP showed lesser surface roughness.

KEYWORDS

surface roughness, nanofiller composites, polishing systems, Filtek Z350 XT, Neospectra, Palfique LX5, ASAP, Diashine

INTRODUCTION

The development of resin composite materials for direct restorations with better mechanical and physical qualities, aesthetics, and clinical lifespan has been prompted by the growing demands in aesthetic dentistry. [1,2] The emergence of nanofilled materials which combine nanomeric particles and nanoclusters in a traditional resin matrix represents the most recent advancement in this field.[3] Recently, for restoring teeth the goal has been to create a composite dental filling material with excellent mechanical properties, appropriate for high stress bearing restorations typical of hybrid composites, and high initial polish and superior polish retention, typical of microfills, for use in anterior and/or posterior tooth restorations.[3] This lead to the development of nanofilled composites which contain nano sized filler particles and higher filler loading which reduces polymerization shrinkage, are easy to handle, and preserve the restorations for an extended period of time. [4,5] An increase in filler content indicates improved mechanical behavior, such as diametral tensile strength, compression strength, and fracture toughness. These properties are particularly significant in teeth that experience high functional stress.

Filtek Z350 which has a combination of a nonagglomerated / nonaggregated (20 nm nanosilica filler) and loosely bound agglomerated zirconia & silica nanocluster with the particle size of 5-20 nm fillers and a cluster particle size of 0.6-1.4 μ which makes it suitable for use in stress bearing areas with high polishability. Similarly, Palfique LX5 nanocomposite consists of supra-nano spherical particles that deliver life like aesthetic restorations, has wide shade matching range (chameleon effect), high wear resistance, less wear to opposing teeth, low shrinkage and good radiopacity. Whereas Neo Spectra ST composite due to the Sphere TEC filler technology, offers optimized handling in a creamy and spreadable low viscosity or a firm and packable high viscosity to enhance placement efficiency.

Along with the aesthetics, the durability of restorations is one of the main concerns in restorative dentistry also the surface topography of the restoration significantly affects the clinical success of resin composite restorations.[6]

Increased surface roughness facilitates mechanical aggregation of the initial bacterial populations, which promotes the process of periodontal disease due to the retention of bacterial plaque causing gingival inflammation, irritation of the tongue, lips, and cheeks, and decreased gloss and increased discoloration of the material surface which can affect the restorations' esthetics.[7] The mentioned unwanted consequences can be avoided by creating a smooth surface which can be obtained by proper finishing and polishing of the composite resin restorations that enhance both the aesthetics and longevity.

At places where the composite restoration is cured against a mylar strip a smooth surfaced restoration is possible,[8] but this was found to be incorrect as different teeth have difference in contour.

A variety of finishing and polishing procedures and materials are available for surface finishing of tooth-colored restorative materials. ASAP system consists of diamond impregnated, flexible polishing spiral wheels. It is designed for optimal adaptation to any surface. It is available in the form of pre-polisher (diamond particles of size 44 microns) and final high shine polisher system (diamond particles of size 3–6-micron).

Whereas Diashine polishing system is a three-step polishing system which consists of a goat hair brush, chamois wheel buff, and cotton wheel buff that allows the user easy access to the entire area.

Various devices are available for the evaluation of surface roughness of composites systems. One such device is an optical profilometer (IIT Delhi), which has a three-dimensional analysis method that provides both qualitative and quantitative representation.

When different techniques are proposed, not only their efficiency in maintaining a smooth surface but also their ability to obtain a gloss surface have to be considered.[6] Therefore this study was performed to evaluate the effect of two finishing and polishing systems on the surface roughness of three different nano-composites.

Materials And Method

Preparation Of Samples-

Twenty specimen discs with each composite were prepared in

standardized stainless steel moulds (8 mm x 2 mm).
Group 1- (n=20) Filtek Z350 XT
Group 2- (n=20) Palfique LX5
Group 3- (n=20) Neospectra

The mould was placed on mylar strip supported by glass slide. The restorative material was placed in one increment directly into the mould with the Teflon coated instrument.

After complete loading of the mould, the material was covered with another transparent mylar strip on the top of the filled mould. A glass slide was placed against the top surface of transparent mylar strip and pressed with light pressure to expel excess material from the mould.

The specimens were polymerized according to the manufacturer's instructions for 3 seconds with a curing light (Woodpecker, i-led) at a consistent intensity of 2300mw/cm^2. After retrieval from the mould, all specimens were stored at 37º C for 24 hrs in containers filled with distilled water for complete polymerization of the specimen.

Treatment Of Specimens
After 24 hours of storage, the specimen discs of each restorative material were subjected to a baseline surface roughening using 600 grit silicon-carbide sand papers under water cooling. Pre-polishing testing of all the composite samples (n=60) was done using optical profilometer.

Grouping Of Samples
After baseline roughening, the specimen discs of each composite resin group were further subdivided into two subgroups (n=10 each) based on the polishing systems used, that is Group 1A, 2A, 3A for ASAP polishing system & Group 1B, 2B, 3B for Diashine polishing system.

Treatment of specimens in Groups 1A, 2A & 3A with ASAP polishing system (n=10 each)
Specimens in sub group A were subjected to ASAP polishing system. First pre polisher was used for polishing the surface of the discs followed by a final polisher. The polishers were used for 10 s at 15,000 rpm with a low-speed hand-piece for each sample.

Treatment of specimens in Groups 1B, 2B & 3B with Diashine (three-step) polishing system (n=10 each)
Specimens in sub group B were subjected to polishing procedure using Diashine polishing system. First Goat hair brush was used for polishing the surface of the discs followed by Chamois wheel buff and then Cotton wheel buff at 15,000 rpm for 10 sec.

All finishing and polishing systems were employed strictly in accordance to the respective manufacturer's instructions and recommendations. The finishing and polishing instruments were replaced with a new instrument, after usage on ten specimens.

Surface roughness was evaluated quantitatively with an Optical Profilometer. Surface roughness was described by Ra (point measure) parameter being the arithmetic mean of absolute ordinate values.

Statistical Methods:
All the data was collected and analyzed using the statistical software Statistical Package for Social Sciences (SPSS 16 Inc, Chicago IL, USA). Independent t-test was used for inter group comparison and for intra group comparison Paired t-test was used for normally distributed data. One way ANOVA followed by Tukey's HSD test, were used among the study population. $P < 0.05$ was considered as statistically significant.

RESULT AND OBSERVATIONS
For intergroup comparison among three groups for two polishing systems was found to be statistically highly significant { pvalue≤0.05} using one-way ANOVA test (Table 1).

For multiple comparison among groups, results revealed that all the differences except between group II and group III in ASAP as well as DIASHINE polishing system was found to be statistically significant (p value≤0.005) using Post-hoctukey's test (Table 2).

Table 1: Intergroup-comparison Among Groups Using One-way Anova

Inter comparison	POST-POLISHING
Group	**ASAP MEAN±S.D.**	**DIASHINE MEAN±S.D.**
Group 1	.01910+0.03	.21670+0.02
Group 2	.13910+0.03	.31290+0.04
Group 3	.11920+0.04	.29170+0.04
p-Value	0.000**	0.000**
Result	Highly significant	Highly significant

Table 2: Post-hoc Analysis

Multiple Comparisons among groups in ASAP post-polishing							
		Mean Difference (I-J)	**Std. Error**	**Sig.**	**Result**	**95% Confidence Interval**	
						Lower Bound	**Upper Bound**
Group 1A	**Group 2A**	-.12000*	.01566	.000	Highly-significant	-.15999	-.08001
	Group 3A	-.10010*	.01566	.000	Highly-significant	-.14009	-.06011
Group 2A	**Group 3A**	.01990	.01566	.645	Non-significant	-.02009	.05989
Multiple Comparisons among groups in DIASHINE post-polishing							
Group 1B	**Group 2B**	-.09620*	.01660	.000	Highly-significant	-.13858	-.05382
	Group 3B	-.07500*	.01660	.000	Highly-significant	-.11738	-.03262
Group 2B	**Group 3B**	.02120	.01660	.638	Non-significant	-.02118	.06358
	*. The mean difference is significant at the 0.05 level.						

DISCUSSIONS
Composite restorative materials are successful in modern biomaterials research, since they replace biological tissues in both appearance and function. The longevity and esthetics of a composite depends on the type of material used as well as the polishing system used. The introduction of nanocomposites, came with the ease of use and ability to provide better esthetics. So, in our study we tested three newer but popular nanocomposites for their surface roughness, before and after polishing.

Proper finishing, surface smoothness and gloss of a restoration are the main characteristics comparable to natural enamel and should be replicated to achieve natural tooth form and esthetics. The handling characteristics and aesthetic properties of resin composites are usually affected by the type of fillers and filler content, but the final outcome of the restoration is strongly influenced by the finishing and polishing techniques.[9] As stated by **Yucci et al**[10] the surface roughness gets influenced by the particle size, hardness and the amount of resin filler, as well as the flexibility of the material used for polishing, which was reinforced by the study of **Alfawaz et al**[11] reported that the surface roughness varies according to the polishing system as well as the resin composite used. It has been shown that one-step systems were superior to or at least comparable to multi-step polishing techniques[12] but in some cases, the results were even product related.

In many studies, a resin composite, polymerized against a mylar strip, was used as a control. As has been previously reported in the literature, a polyester strip provides the smoothest surface. However, in clinical settings, restorations routinely require final treatment for contouring, occlusal adjustment, and the removal of excess material. Due to its high resin content, the layer cured in contact with the strip is more susceptible to wear, and should be removed.[13] Therefore, the quality of the surface achieved using the strip cannot be attained in dental practice, and a proper finishing and polishing of the surface is required. Commercially available finishing and polishing systems have a wide variety of abrasives, such as silicon carbide, aluminum oxide, diamond and silicon dioxide, which are impregnated in rubber and aluminum oxide or diamond silica coated abrasive disks that use one, two or multiple application steps.[14]

In the present study three different nanocomposites were used and their surface roughness was evaluated using two different polishing systems. The surface roughness (Ra) was evaluated with the help of an Optical profilometer. To describe the surface texture (quantitatively), Ra parameter (arithmetical mean roughness) was selected. The Ra value of surface roughness in different subgroups (polishing systems) of the three study groups (nanocomposites) showed that there was

significant inter-group difference. For Filtek Z-350 XT (Group I), inter group comparison of Ra values for surface roughness revealed a gradual decrease in surface roughness when compared with Neospectra and Palfique LX5. **Rodrigues-Junior SA et al (2014)**[15] evaluated the effect of polishing with different polishing systems on the surface roughness and gloss of commercial composites. They stated that the clustered arrangement of the nanofill particles in Filtek Z350 has been suggestive of a wear mechanism in which the clusters break off instead of plucking out the entire particle. This mechanism is believed to be responsible for the polishability and polish retention of this composite. **Alshehri et al (2022)**[16] compared the surface roughness of biomimetic materials and found that the surface roughness of Palfique LX5 was more as compared to Filtek Z350XT this may be due to the fact that when softer resin materials are exposed to staining materials that have a low pH, filler particles are exposed, which may lead to increased surface roughness. Another study done by **Ibrahem EA et al (2023)**[17] evaluated the effect of different polishing methods on the surface roughness of two composites. They observed that Filtek Z350 XT had lower surface roughness due to its chemical composition which contains only nanofillers arranged as nanomers and nanoclusters. When the surface roughness (Ra) in different subgroups in the same material group were compared, our study showed that for Neospectra ST and Palfique LX5, the two and three step polishers produced significant difference in the degree of surface smoothness. The surface roughness of Neospectra ST was better than Palfique LX5, which may be due to the application of the sphere TEC™ technology in the manufacturing of this material which provides natural appearance with perfect adaptability. The presence of spherical fillers imparts excellent strength to the tooth.[18]

When the surface roughness of different sub groups was compared it was found that ASAP gave better results than Diashine in all the types of composites used in the study. As ASAP polishing system is impregnated with small diamond particles in a spiral based system which may render the surface smooth and polished.

Giacomelli L et al (2010)[19] evaluated the effect of different polishing systems namely, PoGo, Enhance and Venus Supra, on Gradia direct, Venus, Venus diamond, enamel plus, Tetric Evoceram and Filtek Supreme XT, and stated that Venus supra resulted in smoother surfaces as it is a multi-step polishing system which effectively abrades both the dispersing matrix and particles of the filling. ENA Shiny& Enamel Plus Shiny, which are similar to Diashine polishing system, used in the study, showed higher surface roughness as compared to the Venus group in a study done by **Kemaloglu H et al (2017)**[20] they stated that the number of procedural steps had no significant effect on the efficacy of finishing and polishing, the hardness of Goat hair brush present in Enamel Plus Shiny may result in rougher surfaces which is proven in our study.

St-Pierre L et al (2019)[21] in his study found that the quality of polished surface depends on the flexibility of the instrument, its shape and hardness. The spiral discs of the polisher guarantee to polish the scars and fissures with greater ease. Venus Supra & EVE Diacomp polishers being diamond impregnated spiral disc-based systems, having size of 40µm and available as pre and post polishers were found to be superior when compared against ENA polishing system.

Szczepaniak M E et al (2022)[22] compared the effect of various polishing systems on Filtek ultimate and Filtek Z250. The best results were obtained after polishing with Super snap and Soflex systems. Polishing with Enamel plus shiny and Jiffy polishing systems produced rougher surfaces as they contain diamond which have a hardness of 10 Moh which might produce deeper scratches on a polished composite, which resulted in greater roughness of the examined material.

Fadabobeh H P S et al (2023)[23] when comparing EVE polishing system with Sof-lex system in polishing of the Filtek Z350, concluded that EVE resulted in reduced surface roughness. This could be due to the fact that EVE polishing system appears to be based on a silicon base with abrasive particles and its lamellar design, which results in greater and more effective contact with the composite surface, creating a more uniform polish.

Based on the results the Null Hypothesis that there would be no differences in surface roughness of the three composites, after polishing them with ASAP and Diashine polishing system was rejected. The limitations of this study included that the study conducted was an in-vitro analysis so the outcomes cannot be applied to clinical scenarios directly. Thereby, further studies are required to determine the best finishing procedure in clinical scenarios.

CONCLUSION

Within the limitations of this study, it can be concluded that Filtek Z350 XT composite when compared with other composites showed the least surface roughness when polished with ASAP as well as Diashine polishing systems. Neospectra gave better results than Palfique LX5 when polished with ASAP and Diashine polishing system. Between the two polishing systems ASAP showed lesser surface roughness. Furthermore, future clinical studies are required to determine which finishing technique is best suited to clinical situations where access is limited and the restoration surfaces are not flat.

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