In Vitro Analysis of Different Polishing Systems on the Color Stability and Surface Roughness of Nanocomposite Resins

Kiran Murthy Dhananjaya1, Suneel V Vadavadagi2, Sultan A Almalki3, Tanya Verma4, Suraj Arora5, Neelagiri Nitish Kumar6

ABSTRACT

Aim: To assess the different polishing systems on the color stability and surface roughness of nanocomposite resins.

Materials and methods: A total of 60 composite resin samples were fabricated. The Tetric N Ceram composite was compacted into the custom-made cylindrical metallic mold of internal diameter 6 × 6 mm. Based on the polishing system used, sixty samples were divided into three groups. Group I: Sof-Lex, group II: Shofu super-snap polishing disks, and group III: Astropol. The samples in each group were immersed in beverage, that is tea. Spectrophotometer was used to measure the color of the samples after staining period. Surface profilometer was used to measure all surface roughness.

Results: Of the three groups, Sof-Lex polishing group reported the least mean value of 0.458 ± 0.118 succeeded by Astropol polishing group (0.494 ± 0.121) and Shofu super-snap polishing group (0.540 ± 0.031) having the higher mean value. Statistically significant difference was found between the different polishing systems calculated by analysis of variance. And color change between the groups was not statistically significant.

Conclusion: We conclude that a composite polished with Sof-Lex was a superior polish compared to Astropol polishing group and Shofu super-snap polishing group. There was only a minimal difference in the color stability of the composite between the groups.

Clinical significance: Excellent finishing and polishing are the critical steps to enhance the esthetics and longevity of the composite restorations. High strength, fracture toughness, surface hardness, optimum polishability, and gloss are the functional properties which need assessment while a resin composite is used for restoration.

Keywords: Color stability, Nanocomposite, Polishing, Surface roughness.

The Journal of Contemporary Dental Practice (2019): 10.5005/jp-journals-10024-2691

INTRODUCTION

To improve the functional results and also success of restorative materials, tooth-colored restorative materials are being used most frequently due to their aesthetic properties. During the recent past, improvements are being made in the resin composites for reaching the ideal esthetics. Due to the most dynamic oral environment, the color stability of the resin composites is a challenge to restorative dentistry.

Composite resins are described as heterogeneous materials comprising a resin matrix usually a dimethacrylate; it reinforces filler which is made of radiopaque glass, and there is a coupling agent, made of silane, which binds the filler to the matrix and polymerization chemicals. To distinguish the macrofilled, microfilled, and hybrid, characteristics of reinforcing fillers and particle size are necessary within each type of composite resin. The particle size which helps in the handling and polishing is reduced to 0.04–1 μm. Nanomers (5–75-nm particles) and nanocluster agglomerate fillers (0.6–1.4 μm) are the components of nanocomposites. It is now revealed that a like hybrid composites, nanocomposites and universal submicron hybrid composites have remarkable mechanical and physical properties, extremely good polishability, and gloss retention producing restorations with better finish and esthetics.

Particle size, degree of hardness, filler load, quality, and polishing material utilized determine the final finish of the composite restoration. Response to abrasive agents by resinous and filler components of composites is unique due to the difference in hardness. Aluminum oxide-coated abrasive (Sof-Lex), silicone disk, tungsten carbide finishing burs, abrasive impregnated rubber cups, abrasive strips, diamond rotary instruments, and polishing pastes are available in the market in either one step or multistep polishing systems.

The surface quality and roughness are improved by finishing and polishing of restoration. The wear resistance and the capacity to abrade opposing tooth structure are predicted by surface hardness of restorative material. There is lack of sufficient information...
regarding the best method used for composite polishing. Therefore, this in vitro study was done to evaluate the different polishing systems on the color stability and surface roughness of nanocomposite resins.

**Materials and Methods**

The present in vitro study was conducted in the Department of Prosthodontics, SJM Dental College and Hospital, Chitradurga, Karnataka.

**Preparation of Nanocomposite Resin Samples**

A total of sixty samples of composite resin were made (Fig. 1). Tetric N Ceram composite (Ivoclar Vivadent AG, Schaan, Lichtenstein) was compacted into the custom-made cylindrical metallic mold made with the internal diameter (6 × 6 mm) using a teflon-coated plastic filling instrument and explorer was used to remove the excess carefully. A mylar strip was sandwiched between the upper surface of composite resin and a glass slide (Fig. 2) of 1–2 mm thickness which was kept before curing with light-activated source (LED curing light); this helps to flatten the surface. After the above steps, through mylar strip and glass slide, the samples were then cured in increments for 60 seconds (Fig. 3) and an additional 20 seconds moved on both sides of the samples after removing the strips and glass slides. Later, the cured samples were stored in distilled water at 37°C for 24 hours, before the finishing procedures. Baseline color of the samples was measured using spectrophotometer.

**Polishing Groups**

Based on the polishing system used, sixty samples were divided into three groups.

Group I: Sof-Lex (3M ESPE, St Paul, MN, USA) polishing system used with light pressure for 30 seconds, applied on disks during polishing.

Group II: Shofu super-snap polishing disks (Shofu Inc., Kyoto, Japan) used from coarse to super fine, each for 15 seconds, total of 60 seconds.

Group III: Astropol (Ivoclar/Vivadent, Liechtenstein, Germany) 10,000 rpm speed used with its finishing grit and high gloss polishing grit.

**Staining**

The beverage used to dip the samples in each group was tea. It was prepared using 2 g of prefabricated tea bag immersed in 100 mL of boiling water for 5 minutes. Period of immersion was standardized to 10 days. Every third day, samples were replenished to avoid contamination by yeast or bacteria. The color of the samples was measured by spectrophotometer after the staining period.

**Evaluation of Surface Roughness**

Pre-roughening was analyzed using surface profilometer (SE 700, Kosaka Lab, Sotokanda Chiyoda-ku Tokyo, Japan) on a flat plane. All specimens were again subjected to evaluation of surface roughness following polishing procedure. With a cutoff value of 0.8 mm, the samples were measured five times, and they have a transverse length of 0.8 mm, and a stylus speed of 0.1 mm/second near the center of each specimen using a profilometer. On each polished specimen, six measurements were recorded by turning the specimen 45° after each measurement. For each finishing method, a mean value was calculated for each specimen.
**Statistical Analysis**

SPSS 17.0 for Windows (SPSS, Inc., Chicago, IL, USA) software was used to analyze the data. Analysis of variance (ANOVA) was used to evaluate the effects of polishing systems, color stability, and surface roughness. \( p < 0.05 \) was considered as the level of significance.

**Results**

Table 1 shows mean and standard deviation of different polishing system on surface roughness. Sof-Lex polishing group reported the least mean value of 0.458 ± 0.118 succeeded by Astropol polishing group (0.494 ± 0.121) and Shofu super-snap polishing group (0.540 ± 0.031). Table 2 shows the comparison of different polishing system on surface roughness. Statistically significant difference (\( p = 0.001 \)) was found between the different polishing systems revealed by analysis of variance.

No significant (\( p = 0.624 \)) difference was found in the color change values between the groups. With ascending order of the values in color change, Sof-Lex group had minimal color changes amongst the groups, after immersed in the liquid media (2.56 ± 0.22–1.02 ± 0.08), which was followed by Astropol group (3.10 ± 0.14–1.46 ± 0.63) and Shofu super-snap (2.98 ± 0.03–1.90 ± 0.16) (Table 3).

Table 4 reveals the multiple comparisons among polishing groups. It was found that group I vs group II and group II vs group III groups (\( p = 0.001 \)) showed statistically significant difference. But there was no significant difference between group I vs group III (\( p > 0.05 \)).

**Discussion**

After any restorative procedure, finishing and polishing procedures are crucial clinical steps essential to restore an anatomical and morphological form of the tooth. This is the most important factor to maintain clinical durability, good esthetic appearance, better optical compatibility with natural enamel tissue, surface gloss, and also preventing the discoloration plus staining of the restoration is by obtaining a smooth surface.7,8

To improve the mechanical properties of composite resin, surface finishing and polishing technique is mandatory. In the present study, to check the surface roughness and color stability, Tetric N Ceram nanohybrid composites are used. There was no significant color change after immersion in the liquid media. A similar study was done by Baig et al.9 which was an in vitro study where the composite material used was Tetric N Ceram. Mouth rinses were used as the staining agent which includes Listerine, Eludril, Phosflur, Amflor, and Rexidin. Color spectrophotometer was utilized to record the color values. The mean color value (before and after immersion) had a significant reduction with non-alcohol-containing mouth rinses.

A study done by Patel et al.10 determined the effect of polishing systems on the surface finish of nanohybrid composite restorations. Filtek Z350 and Tetric N Ceram were used in this study. PoGo, One Gloss, and Sof-Lex spiral were the polishing systems. Surface profilometer analyzed the surface finish. They concluded that Tetric N Ceram was a better polishing system than Filtek Z350.

In our study, we have made use of three different polishing systems. There was only minimal surface roughness and better color stability with Sof-Lex polishing group followed by Astropol polishing group and Shofu super-snap polishing disks. This was similar to a study done by Kumari et al.\textsuperscript{11} who deduced that compared to the diamond polishing paste, Sof-Lex polishing system makes the nanocomposite resin more resistant to discoloration.

Abzal et al.\textsuperscript{12} found in the study that aluminum oxide incorporated in Sof-Lex spiral wheel had better surface finish, less rough compared to the diamond abrasives in Astropol even though the latter gave a good surface finish. The primary cause of this is the nondisplacement of composite filler particles by Sof-Lex spiral wheel as compared to the less flexible Astropol points. Homogenous abrasion of fillers and the resin matrix occur due to aluminum oxide in Sof-Lex spiral wheel. In addition, the Sof-Lex wheel aptly adapts to the surface of the composite resin.

**Table 1:** Mean value and standard deviation of different polishing system on surface roughness

| Groups          | n   | Mean ± Std. deviation |
|-----------------|-----|-----------------------|
| Group I-Sof-Lex | 20  | 0.458 ± 0.118          |
| Group II-Shofu super-snap | 20  | 0.540 ± 0.031          |
| Group III-Astropol | 20  | 0.494 ± 0.121          |

**Table 2:** Comparison of different polishing system on surface roughness

| Groups          | Mean ± Std. deviation | F value | p value | Sig. |
|-----------------|-----------------------|---------|---------|------|
| Group I-Sof-Lex | 0.458 ± 0.118         | 22.283  | 0.001   | HS   |
| Group II-Shofu super-snap | 0.540 ± 0.031 |         |         |      |
| Group III-Astropol | 0.494 ± 0.121 |         |         |      |

\( p < 0.05 \); HS, highly significant

**Table 3:** Color change values for the nanocomposite resins at baseline and after immersion to liquid

| Groups          | Baseline    | After immersion | F value | p value | Sig. |
|-----------------|-------------|-----------------|---------|---------|------|
| Group I-Sof-Lex | 2.56 ± 0.22 | 1.02 ± 0.08     | 25.289  | 0.624   | NS   |
| Group II-Shofu super-snap | 2.98 ± 0.03 | 1.90 ± 0.16     |         |         |      |
| Group III-Astropol | 3.10 ± 0.14 | 1.46 ± 0.63     |         |         |      |

NS, not significant
The nondisplacement of the composite filler particles by Sof-Lex makes the aluminum oxide (Sof-Lex) disks to provide better surface smoothness, and also, the fillers in composite are very tiny that their stiffness is reduced, so their malleability promotes a homogeneous abrasion of the fillers and the resin matrix Yap et al.\textsuperscript{13} The concept of homogeneous abrasion was also supported by Mitra et al.\textsuperscript{14}

The medium used in the present study was tea. It is due to the compatibility of the polymer phase with yellow colorants the absorption and penetration of the colorants occur into the organic phase of the resin-based materials. Large amount of staining agents like gallic acid is present in tea therefore has better staining capacity. The above concept was supported by a study done by Nordbø et al.\textsuperscript{15}

Surface profilometer was used in our study to measure the surface roughness. Good resolution: vertical resolution is usually in the nm level, high speed, reliability: cannot be damaged by surface wear or careless operators, spot size or lateral resolution, which ranges from a few micrometers down to sub-micrometer. The surface roughness of the samples was due to polishing procedures in our study.\textsuperscript{11}

Changes in the appearance, retention of plaque, surface discoloration, and gingival inflammation is due to the presence of irregularities in composites. Also, the reduction in hardness and increase the wear of these restorations could be due to surface roughness of composites. So the quality of the surface finishing and polishing affects esthetics and longevity of restorations.\textsuperscript{16}

The limitation of the study is that only one nanocomposite was used. To come to an appropriate conclusion on the surface roughness and color stability, newer modified nanocomposites must be included. There were only three polishing systems which were examined. In future studies, many other composite polishing systems need to be evaluated.

**Conclusion**

Within the scope of this \textit{in vitro} study, we conclude that when the composites were polished with Sof-Lex, they provided a superior polish compared to Astropol polishing group and Shofu super-snap polishing group. There was only a minimal difference in the color stability of the composite between the groups.

**References**

1. Hotwani K, Thosar N, Baliga S. Comparative \textit{in vitro} assessment of color stability of hybrid esthetic restorative materials against various children’s beverages. J Conserv Dent 2014;17(1):70–74. DOI: 10.4103/0972-0707.124154.

2. Veena Kumari R. Evaluation of surface roughness of composite resins with three different polishing systems and the erosive potential with apple cider vinegar using atomic force microscopy- \textit{an in vitro} study. Acta Scientific Dental Sciences 2019;3(3):08–16.

3. Gonçalves MA, Teixeira VC, Rodrigues SS, et al. Evaluation of the roughness of composite resins submitted to different surface treatments. Acta Odontol Latinoam 2012;25(1):89–95.

4. Madhyastha PS, Naik DG, Srikant N, et al. Effect of finishing/polishing techniques and time on surface roughness of silorane and methacrylate based restorative materials. Oral Health Dent Manag 2015;14:212–218.

5. de Oliveira Lima M, Catelan A, Hernandes NM, et al. In vitro evaluation of the effect of different polishing techniques on the surface roughness of composite resins submitted to at-home and in-office bleaching procedures. J Conserv Dent 2015;18(6):483–487. DOI: 10.4103/0972-0707.168820.

6. Chour RG, Moda A, Arora A, et al. Comparative evaluation of effect of different polishing systems on surface roughness of composite resin: \textit{an in vitro} study. J Int Soc Prevent Communit Dent 2016;6(Suppl 2):166–170. DOI: 10.4103/2231-0762.189761.

7. Antonsen SA, Yazici AR, Kilinc E, et al. Comparison of different finishing/polishing systems on surface roughness and gloss of resin composites. J Dent 2011;39(1):e9–e17. DOI: 10.1016/j.jdent.2011.01.006.

8. Erdemir U, Yıldız E, Eren MM, et al. Effects of polishing systems on the surface roughness of tooth-colored materials. J Dent Sci 2013;8(2):160–169. DOI: 10.4103/0972-0707.166448.

9. Baig AR, Shori DD, Shenoi PR, et al. Mouthrinses affect color stability of composite. J Conserv Dent 2016;19(4):355–359. DOI: 10.4103/0972-0707.166448.

10. Patel B, Chhabra N, Jain D. Effect of different polishing systems on the surface roughness of nanohybrid composites. J Conserv Dent 2016;19(1):37–40. DOI: 10.4103/0972-0707.173192.

11. Kumari RV, Nagaraj H, Siddaraju K, et al. Evaluation of the effect of surface polishing, oral beverages and food colorants on color stability and surface roughness of nanocomposite resins. J Int Oral Health 2015;7(7):63–70.

12. Abzal MS, Rathakrishnan M, Prakash V, et al. Evaluation of surface roughness of three different composite resins with three different polishing systems. J Conserv Dent 2016;19(2):171–174. DOI: 10.4103/0972-0707.178703.

13. Yap AU, Ng JJ, Yap SH, et al. Surface finish of resin-modified and highly viscous glass ionomer cements produced by new one-step systems. Operative Dentistry-University of Washington 2004;29(1):87–91.

14. Mitra SB, Wu D, Holmes BN. An application of nanotechnology in advanced dental materials. J Am Dent Assoc 2003;134(10):1382–1390. DOI: 10.14219/jada.archive.2003.0054.

15. Nordbø H, Attramadal A, Eriksen HM. Iron discoloration of acrylic resin exposed to chlorohexidine or tannic acid: a model study. J Prosthet Dent 1983;49(1):126–129. DOI: 10.1016/0022-3913(83)90252-4.

16. Gharechahi M. Effect of surface roughness and materials composition on biofilm formation. J Bio Nanotech 2012;3(4):541–546.