Comparative Evaluation of the Effect of Tooth Brushing on Surface Gloss and Roughness of Three Different Resin Composites: An In-Vitro Study

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Abstract

Background: Composite resins are extensively used due to their excellent optical and superior adhesive properties. One innate disadvantage of these materials is that their color changes over time. Routine oral hygiene practices also has an impact on the surface texture. Improvements in filler technology has helped in combatting these issues. Estelite® α, a supra-nano spherical filled resin composite is one such recently introduced material. Aim of the study: To compare the changes in surface gloss and roughness of three different resin composites following simulated tooth brushing at varying time intervals. **Methodology:** Estelite® α – Supranano (Group I), Filtek™ Z350 – Nanofilled (Group II) and Filtek™ P60 – Microhybrid composite (Group III) discs were fabricated using customized molds (n=44 per group). Sof-Lex® finishing and polishing discs were used sequentially from coarse to superfine for an optimal surface finish. Baseline surface gloss and roughness values were recorded using glossmeter and optical profilometer. The discs were then subjected to custom-made motor-assisted toothbrush abrasion along with a toothpaste slurry, under a constant load of 2N. The surface gloss and roughness were re-assessed at intervals of 5, 15, 30 and 60 minutes of tooth brushing. Statistical analysis was performed using Wilcoxon test for intra-group comparison and one-way ANOVA for inter-group comparison. **Results:** Tooth-brushing influenced the surface roughness and gloss of all tested materials. The supra-nano filled composite (Estelite® α) exhibited maximum gloss and minimum roughness while the microhybrid composite (Filtek™ P60) exhibited minimum gloss and maximum roughness, at the end of the testing period. **Conclusion:** From the present study, it was concluded that supra-nano composites maintained the best surface texture even after 60 minutes of simulated toothbrushing.

Keywords: Supra-nano Filled Composite, Microhybrid Composite, Nano-filled Composite, Gloss, Surface Roughness

Introduction

Among a plethora of restorative materials currently available, resin based composites have attained the zenith of its usage owing to its esthetics and its ability to bond to the tooth structure. Resin-based composites (RBCs) have a matrix containing the methracrylate monomers, reinforced fillers and an interphase of silane coupling agent. The composition of RBCs has been in a constant state of flux since its introduction to dentistry over five decades ago, so as to optimally enhance their properties.[1]

Optical properties of RBCs which are influenced by factors such as the surface roughness and gloss are of paramount importance ultimately contributing to its success.[2]

Composites with an average surface roughness above 0.2 μm beckons bacterial adherence. Also, the patient's tongue can perceive a surface to be rough at a magnitude as low as 0.3 μm.[3, 4]

A rough surface subsequently can discolor altering the esthetics. A plausible sequel include

plaque accumulation, gingival irritation, secondary caries and even wear of the opposing teeth. An unaltered surface aids in reduced discomfort to the patient and helps maintain oral hygiene.[5]

roughness and gloss are dependent on the composite and polishing system employed[2,8-12].Filler particle is a significant component which influences the optical properties, wear resistance & surface texture of resin composites. For a superior surface texture it would be ideal to moderate the size of the filler.[13]

Table 1. Product profile of the tested resin composites used in the study

Material	Manufacturer	Classification	Composition				
			Filler Load	Matrix	Filler Type	Avg. Particle Size	Particle Size Range
Estelite® α	Tokuyama, Japan	Submicron (Supranano)	71 vol% (82 wt%)	Bis-GMA, TEGDMA	Silica-zirconia	0.2µm	0.1-0.3 µm
Filtek™ Z350	3M ESPE, USA	Nanofilled	78.5 vol% (63.3 wt%)	Bis-GMA, Bis-EMA, UDMA with small amounts of TEGDMA.	Silica Zirconia -silica clusters	20nm n.i.	n.i. 0.6-1.4 µm
Filtek™ P60	3M ESPE, USA	Microhybrid	61 vol% (78.8 wt%)	Bis-GMA, Bis-EMA, UDMA	Zirconia -silica	0.6 µm	0.01-3.5 µm

Surface gloss is a measure of the ability of the surface to reflect light and its perception originates from the geometrical distribution of the light reflected by the surface.[6] Out of the several types of gloss cited in literature, contrast gloss is of prime importance for RBCs. Contrast gloss is the proportion of specular reflection to diffuse reflection.[7] Higher gloss ensures a better esthetic harmony of the restoration with the adjacent teeth.

The first ever documented literature on the association between gloss and surface roughness of resin materials was in 1984 by O'Brien et al.[7] Other studies have shown that the surface

Thus the purpose of this study was to compare and evaluate the effect of tooth brushing on surface gloss and roughness of a supra- nano filled composite (Estelite® α) with nanofilled composite (Filtek™ Z350) and microhybrid composite (Filtek™ P60), using a gloss-meter and profilometer respectively.

Materials and Methods

Three commercially available composites were selected for the study based on filler size namely, Group I – Supranano - Estelite® α (Tokuyama Dental Corp., Japan); Group II – Nanofilled - Filtek™ Z350 (3M ESPE, St. Paul,

MN, USA) & Group III – Microhybrid - Filtek™ P60 (3M ESPE, St. Paul, MN, USA). Product profile of the tested resin composites used in this study is depicted in Table 1.

A total of 132 plastic molds with an outer diameter of 8.04±1 mm & thickness of 3.36±1 mm were prepared. Each group consisted of 44 specimens. Each mould was filled with the experimental composite as per the groups (n=44) to slight excess using a composite filling instrument and a microscopic cover glass was placed over the top of the uncured composite. A load was applied for 20 seconds to extrude the excess material. The specimens were cured for 40 seconds each from both directions using a visible light curing unit to ensure complete curing. The specimens were polished using varying grades of Sof-Lex® discs (3M ESPE, St. Paul, MN, USA) and baseline surface gloss & surface roughness measurements were recorded using glossmeter and profilometer respectively. Following this, each composite group was subdivided into 4 subgroups each (n=11) and were subjected to simulated tooth-brushing using a customized motorized device. The specimens were fixed on holders under the toothbrush head. A slurry of dentifrice (Colgate Total®, Colgate-Palmolive GmbH, Hamburg, Germany) with RDA 70 and distilled water (AviChem Deionized water, Avinash Chemicals, Bangalore) were taken in a 1:1 weight ratio. Each composite disc was sufficiently covered with the slurry and care was taken to see that the brush bristles were perpendicular to the surface of each sample. Brushing was performed at intervals of 5, 15, 30 and 60 minutes under a constant load of 2N. After testing at each interval, the specimens were removed from the sample holders, cleaned for 1 min with an air/water spray and dried for 24 h. The specimen were re-evaluated for their surface gloss and roughness at every interval.

Gloss measurements were assessed using a specular glossmeter (ETB-0686 Glossmeter, state standard GB 9754-88, GB 9966.5 and international standard ISO 2813) and expressed in gloss units (GU). The glossmeter was equipped with a square measurement area of 9 mm×15 mm and a 60˚ angle. The device had to be calibrated before each use. To enable precision at every measurement, a black plastic mold was placed over the specimens during measurements. This also ensured the elimination of discrepancies from the ambient light. The average surface roughness (μm) was measured with an optical profilometer (Veeco Wyko® NT1100) using a non-contact tip.

After performing the surface roughness test, one representative specimen from each group for baseline and 60 minutes was prepared for the SEM examination. Specimens were mounted on aluminum stubs. Each specimen was examined under the SEM (Leitz Wetzlar Ortholux® II Pol, Canada) at a magnification of 200X with an accelerating voltage of 10 kV, and photographs were taken.

Descriptive statistics of surface gloss and roughness for all the composite specimens were analyzed and expressed in terms of mean and standard deviation. For the intra-group comparison of gloss and roughness Wilcoxon test was used. One-way ANOVA was used for inter-group comparison of the two components.

Results

Tables 2 and 3 depict the gloss and roughness values of each of the resin composites at baseline and every interval of tooth brushing, respectively.

The surface gloss of the composites at baseline had a narrow distribution, ranging from 82.02 GU (Group II) to 83.32 GU (Group I). After 60 minutes of simulated brushing, the gloss values were distributed over a wider spectrum, ranging from 51.89 GU (Group III) to 63.39 GU (Group I).

Table 2. Surface gloss of resin composites at baseline and different time intervals

Groups	Resin Composite	Baseline	5 mins	15 mins	30 mins	60 mins
Group I	Supra-nano filled	83.32	76.63	71.48	66.95	63.29
Group II	Nano-filled	82.02	74.63	68.18	63.95	60.09
Group III	Microhybrid	82.42	68.13	60.82	55.35	51.89

Table 3. Surface roughness of resin composites at baseline and different time intervals

Groups	Resin Composite	Baseline	5 mins	15 mins	30 mins	60 mins
Group I	Supra-nano filled	0.02	0.03	0.04	0.05	0.05
Group II	Nano-filled	0.03	0.04	0.05	0.06	0.07
Group III	Microhybrid	0.06	0.07	0.10	0.12	0.15

Group I exhibited the maximum gloss after simulated brushing. Post-treatment values of Groups I and II were not statistically significant ($p<0.05$). Between Groups I and III, Group III recorded minimum gloss ($p>0.05$).

The surface roughness ranged from 0.028μm (Group I) to 0.061μm (Group III) at baseline. Following 60 minutes of brushing the values ranged from 0.053 μm (Group I) to 0.153 μm (Group III).

Inter-group comparison of surface roughness was analogous to the surface gloss viz. Group I exhibited minimum surface roughness.

Discussion

One of the restorative materials used lavishly in dentistry are composite resins due to their inherent properties and remarkable adhesion to enamel and dentin. However, the limitation of these materials are their surface characterizations which change over time thus warranting a replacement.[14] Additionally, routine home care measures such as brushing and the use of a dentifrice may roughen the surface which ultimately can harbor bacteria and imbibe discoloration.[15] Advancements in filler technology has led to the introduction of newer commercially available composites that claim to provide the best possible surface gloss and finish. The present study was undertaken to compare the changes in surface

gloss and roughness of three different resin composites following simulated tooth brushing at varying time intervals.

This study was conducted for a total brushing time of 60 minutes since this time duration would cumulatively correspond to a period of 2 to 6 years, as observed from previously reported studies.[16,17] The dentifrice used and the toothbrush characteristics have an impact over the abrasion of the superficial layer of the restoration. The abrasiveness of the dentifrice should enable efficient cleaning and at the same time cause minimal alteration to the existing tooth structure. A measure of the dentifrice abrasiveness is radioactive dentin abrasion or radioactive relative abrasion (RDA).[3] According to the values proposed by ADA, it can span between 30 and 250. Costa et al[3] compared the effect of various dentifrices on surface roughness and gloss of resin composites and it was concluded that dentifrices containing a lower RDA number may promote less reduction in gloss and less increase in surface roughness for composites of different particle sizes. Our study used Colgate total® dentifrice with an RDA of 70 and has medium abrasiveness.

The principal objectives in our study was to assess the change in surface gloss and roughness of the three resin composites namely Supra-nano filled composite (Group I), nano-filled composite (Group II) and Microhybrid composite (Group III). It was observed that at baseline the gloss values ranged from 82.02 (Group II) to 83.32 (Group I) GU. At the end of 60 minutes of simulated brushing, gloss was highest for Group I (63.29 GU) and lowest for Group III (51.89 GU). Between Groups I and II (60.09 GU), there was not a statistical difference, though Group I proved to be glossier. Thus, with increasing brushing time, a reduction in gloss occurs. These findings are in accordance with other studies cited in literature.[3,6,17,18] A reason for better gloss retention in Groups I and II could be due to the higher filler loading which achieve high surface gloss even after simulated tooth-brushing. As evident from table 1, Groups I (71 vol%) and II (78.5 vol%) have better filler loading compared to Group III (61 vol%).

It is interesting to note that though higher filler loading was seen in Group II, Group I still performed better. It is thus reasonable to state that the filler shape has a command over surface gloss. The filler shape of supra-nano filled composite, Estelite® α (Group I) is spherical, with a narrow range of 0.1 to 0.3 µm-sized particles. Therefore, Group I composites might reflect light uniformly with lower diffusion/absorbance than the other groups. Larger fillers, as seen in Group III (0.6µm), would produce more diffuse reflections as against smaller fillers, as seen in Groups I (0.2 µm) and II (20nm), which is translated as a reduced surface gloss.

The results from the surface roughness analysis reveal at baseline, the values extended between 0.028 (Group I) to 0.061 (Group III) µm. At the end of 60 minutes of simulated brushing, surface roughness is minimum for Group I (0.053µm) and maximum for Group III (0.153µm). Between Groups I and II (0.072µm), there was not a statistical difference, though Group I proved to be smoother. This goes to prove that increasing the brushing time would lead to an increase in the surface roughness with literature also presenting very similar results.[3,19]

Group I composites confer an advantage over others due to the presence of nano-sized filler particles which ensures a stable association of filler particles within the composite matrix. The plucking away of loose fillers from the matrix leads to concavities which exemplifies as surface texture irregularities which could be attributed to our results from

Group III. Better bonding of fillers with the matrix would lead to low wear rates of nano-particle composites. Additionally, the reduced filler particle size and increased filler loading, would improve the wear resistance. Group I (0.2µm) and II (20nm) composites have reduced particle size compared to group III (0.6µm). Finer particles lead to an increase in filler surface area. Representative samples from baseline and at 60 minutes for the three groups were viewed under SEM which were in strong correlation with our inferences made from surface roughness analysis.

Our study used a force of 2N, which corresponds to 204 g. ISO specification on wear is between 50g and 250g[20]. Other studies used 200g, 250g, 350g or 500g.[21-24] As inferred from the previous studies, the materials are affected by the magnitude of the force applied. The 2 N of force used in this study is well within the prescribed ISO protocol.

One of the innate limitations is the virtue of our study that is, being *in-vitro*. Differences in surface deterioration observed for specific composite materials in laboratory tests seem to have no direct clinical correlation as other factors like saliva, food items, contact with mucosal surfaces and masticatory load also play a role. Seldom have these factors seemed to compensate tooth-brushing effects and lead to a more patient-related than material-related deterioration of the surfaces. Furthermore, a roughened surface might beckon bacterial adherence. Future studies considering these variables are indicated.

Conclusion

Within the limitations of the present study, it was concluded that:

- Surface gloss of all composite materials decreased with increasing brushing time
- Surface roughness of all composite materials increased with increasing brushing time
- Supra-nano filled composites, Estelite® α (Group I) was least affected by the simulated brushing, that is it retained maximum gloss and exhibited minimum roughness, among the tested composites
- Micro-hybrid composite, Filtek™ P60 (Group III) was the most affected by simulated brushing exhibiting minimum gloss and maximum roughness, among the tested composites

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