Surface roughness comparison of methacrylate and silorane-based composite resins after 40% hydrogen peroxide application

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ABSTRACT

The change of the tooth colour could be restored with bleaching. The tooth bleaching will affects the surface roughness of the composite resins. Recently, the material basis for composite resins has developed, among others are methacrylate-based and silorane based composite resins. The objective of this study was to distinguish the surface roughness value of methacrylate-based composite resin and silorane based composite resins. This research was quasi-experimental. The sample used in this study were methacrylate and silorane based composite resins in discs form, with the size of 6 mm and the thickness of 3 mm, manufactured into 20 specimens and divided into 2 groups. The control group was immersed in the artificial saliva, and the treatment group was applied with 40% hydrogen peroxide. The result of the experiment analyzed using unpaired sample t-test showed significant differences in the average value of the surface roughness after the application of 40% hydrogen peroxide. The average value of methacrylate and silorane based composite resins were 2.744 µm and 3.417 µm, respectively. There was a difference in the surface roughness of methacrylate and silorane based composite resin compounds after the application of 40% hydrogen peroxide. The surface roughness value of the silorane-based composite resin was higher than the methacrylate-based.

Keywords: Surface roughness, methacrylate based composite resin, silorane based composite resin, 40% hydrogen peroxide

INTRODUCTION

Nowaday's society is craving for dental health not only for the well-being reason but also for beauty. A smile with bright white teeth will give a positive image in appearance, communication, and social life. However, it is often found disharmonies in the smile, especially seen from the anterior teeth colour changes.[1]

Tooth colour changes occurred extrinsically and intrinsically. Extrinsic tooth colour changes caused by deposits on the tooth surface. Intrinsic tooth color changes caused by the stains contained in the tooth enamel and dentine.[2] Tooth colour changes can be restored in various ways, for example, through bleaching, veneering, and enamel microabrasion.[3]

Tooth whitening is mostly used today due to the simple and noninvasive procedures. Tooth whitening is a chemical process involved an oxidation-reduction reaction. The oxidizing agent penetrates into the pores of the crystalline structure of the tooth enamel and oxidizes the deposited stain.[4]

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Tooth whitening can be done in two ways: internally and externally. Internal bleaching (intracoronal bleaching) performed on non-vital teeth that have been well treated. External bleaching (extracoronal bleaching) performed on discoloured vital teeth. External bleaching can be done in two techniques: home bleaching techniques performed individually but with monitoring and in-office bleaching techniques performed by dentists.[5] In-office bleaching techniques usually use high-concentration bleaching agents, such as 15%-50% hydrogen peroxide. A high concentration tooth whitener will speed up the tooth whitening process.[6,7]

Tooth whitening applied to the anterior teeth, which is often found the existence of composite resin restoration.[8] Composite resin is an aesthetic restoration material due to its resemblance to the original tooth color. The composite also used as an anterior dental restoration material due to the good aesthetical properties.[9]

Along with the development of technology in the manufacture of composite resins, various attempts were made to obtain an aesthetic composite resin. Recently, the material basis for composite resins has developed, among others are methacrylate-based and silorane based composite resins. The silorane monomer is based on the reaction between oxirane and siloxane molecules. Silorane has a low polymerization shrinkage. The polymerization process occurs with the ring-opening process, in contrast to a methacrylate-based matrix which the polymerization process initiated on the double bonding addition in the functional group.[10]

The tooth whitening process has a side effect on the composite restoration materials in the form of white discolouration and an increase in the composite surface roughness. Surface roughness is one of the important physical properties of restorative materials. The roughness of the restoration surface will improve bacterial attachment, increased plaque retention, tooth discolouration, and gingival irritation.[11]

Previous research reported that there was a physical change in the composite resin after the application of 35% hydrogen peroxide, one of them is the increased surface roughness of the composite resin. According to a research conducted by Turker and Biskin,[12] tooth whitening with the home-bleaching techniques showed an increased roughness on the surface of the composite restoration materials.[12] Also, Garcia-Godoy reported that there was no increase in the surface roughness of the composite restoration materials after in-office bleaching.[13]

Based on the theoretical information described before, the purpose of this study was to distinguish the surface roughness value of methacrylate and silorane based composite resin materials after the application of 40% hydrogen peroxide by calculating the difference of the surface roughness value.

METHODS

This study was experimental in-vitro. The study samples were 40 composite resin specimens consisted of 20 methacrylate-based specimens and 20 silorane-based specimens in the disc forms with a diameter of 6 mm and thickness of 3 mm.

The confidence level was 95% ($Z\alpha = 1.96$); 80% test power ($Z\beta = 0.84$); standard deviation (S) and d value were the average difference value of both resin surface roughness, based on the results from Atali and Topbasi's research using the largest Sd value ($S = 1.78$; $d = 1$). Based on the formula of sample size obtained $n = 20$ for each group. Research analysis unit used was the surface roughness tester (Surflight® SE1200).

RESULTS

A study of the difference of the surface roughness value of methacrylate and silorane-based composite resin after the application of 40% hydrogen peroxide application was performed on as much as 40 composite resin specimens consisted of 20 specimens of methacrylate-based composite resin and 20 silorane-based specimens. All samples divided into two groups, 10 specimens of the control group and 10 specimens of the treatment group.

The control specimen group was immersed in the artificial saliva for 24 hours. In the treatment specimen group, after immersion in artificial saliva for 24 hours, samples were applied with 40% hydrogen peroxide for 20 minutes. The composite resin surface roughness measurement

Table 1. Methacrylate-based composite resin surface roughness value

No	Control Group	Treatment Group
1	0.614	4.676
2	0.793	1.432
3	1.850	3.827
4	2.171	3.967
5	0.901	2.198
6	0.979	2.496
7	0.245	3.127
8	1.241	0.612
9	1.881	3.360
10	1.074	1.734
Total	**11.749**	**27.429**
Mean	**1.1749**	**2.7429**

Table 2. Silorane-based composite resin surface roughness value

No	Control Group	Treatment Group
1	1.206	3.141
2	1.201	1.194
3	0.944	0.495
4	1.988	2.321
5	1.103	4.609
6	3.418	3.418
7	0.853	6.463
8	2.084	3.106
9	3.114	1.696
10	1.136	3.591
Total	**17.047**	**34.167**
Mean	**1.7047**	**3.4167**

Table 3. Surface roughness average value of methacrylate and silorane-based composite resins

Specimen	Mean	Standard Deviation
Methacrylate-Control	1.1749	0.6146
Methacrylate-Treatment	2.743	1.2734
Silorane-Control	1.7047	0.9212
Silorane-Treatment	3.4167	2.25178

was performed using surface roughness tester (Surfcorder® 1200). The surface roughness value unit was stated in μm and expressed in Ra.

The surface roughness value of methacrylate-based composite resin measurement results can be seen in Table 1. Based on data presented in Table 1, the average value of the surface roughness of the treatment group (applied with 40% hydrogen peroxide) was higher than the average value of the surface roughness of the control group.

The surface roughness value of silorane-based composite resin measurement results can be seen in Table 2. Based on data presented in Table 2, the average value of the surface roughness of the treatment group (applied with 40% hydrogen peroxide) was higher than the average value of the surface roughness of the control group.

Based on the analysis of data presented in Table 1 and Table 2, obtained the initial data conception, as presented in Table 3.

Based on Table 3, the average surface roughness value of the silorane-based composite resin in control group was higher than the methacrylate-based composite resin in control group. Also, the average surface roughness value of the silorane-based composite resin in the treatment group was higher than the methacrylate-based composite resin in the treatment group (Fig. 1).

The surface roughness value of methacrylate and silorane based composite resin were then tested the normality using the Shapiro-Wilk test as presented in Table 4. Based on the normality test result, the surface roughness average of methacrylate-based composite resin showed an insignificant result ($p>0.05$). Different parametric analysis result using the t-test was presented in Table 5. Based on the t-test result, the surface roughness average of silorane-based composite resin showed a significant result ($p<0.05$). Different non-parametric analysis result using the Mann-Whitney test was also presented in Table 5.

Table 5 showed that there was a significant difference between the surface roughness value of methacrylate-based composite resin ($p=0.004$) and silorane-based composite resin ($p=0.032$) in the treatment group. Also, in the control group, there was an insignificant value of surface roughness ($p=0.148$) between the methacrylate-based composite resin and the silorane-based composite resin. In the treatment group obtained an insignificant surface roughness value ($p=0.422$) between the methacrylate-based composite resin and the silorane-based composite resin.

The statistical test results above suggested that there was a significant difference in the surface roughness value of the methacrylate and silorane based composite resin after the application of 40% hydrogen peroxide (the treatment group.

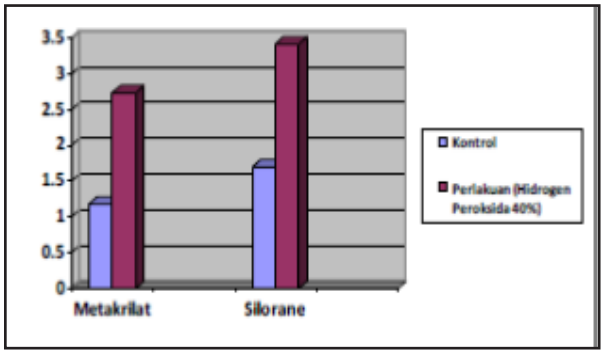

Figure 1. Surface roughness average value of Methacrylate and Silorane Based Composite Resins

Table 4. Surface roughness value of methacrylate and silorane based composite resins normality test result

Surface roughness	Statistical measurements			Normality test data* (P-value)
	Mean	SD	Range	
Methacrylate-Control	1.175	0.615	0.245-2.171	0.628
Methacrylate-Treatment	2.744	1.273	0.611-4.676	0.973
Silorane-Control	1.705	0.921	0.853-3.418	0.024
SiloraneI-Treatment	3.147	2.252	0.495-7.551	0.597

***based on the Shapiro-Wilk test**

Table 5. Comparison of surface roughness value of methacrylate and silorane based composite resins

Surface roughness	Group		Mean
	Control (Saliva)	Treatment (40% H_2O_2 application)	
Methacrylate (SD)	1.175 (0.615)	2.744 (1.273)	t=3.509 p=0.004
Silorane (SD)	1.705 (0.921)	3.417 (2.252)	Z_{M-W} =1.89
Median	1.204	3.123	p=0.032
t-test	t= 1.513 p=0418	t= 0.823 p=0.422	

DISCUSSION

From the results of the statistical analysis suggested that there was an insignificant difference in the surface roughness value between the methacrylate-based composite resin and the silorane-based composite resin immersed in the artificial saliva for 24 hours. The same result was also found in the composite resins applied by 40% hydrogen peroxide. The roughness value of the silorane-based composite resin surface was higher than the methacrylate-based composite resin.

The composite resin surface roughness values were influenced by the particle size and the filler content in the composite resins.[14] In this study, the silorane-based composite resin contains the micro-hybrid fillets of 0.04-1.7 µm, whereas the methacrylate-based composite resin contains the nanofiller with nanoparticles of 20-70 nm and nanocluster with the average of 0.6 µm (2-20 nm particles).[15] The free radicals produced by hydrogen peroxide break the bonds on the resin matrix and the filler. This condition will release the resin matrix or filler, resulting in a rough composite resin surface,[8] because the silorane-based composite resin particle is larger, resulting in the higher surface roughness value than the methacrylate-based composite resin.

The roughness value of the composite resin surface applied by 40% hydrogen peroxide was 40% higher than the surface of the composite resin with no application. This result was consistent with the opinion of Atali and Topbasi in 2011 stated that there was a significant difference in the roughness value of the Filtek Silorane composite resin between the control group and the group applied with 38% hydrogen peroxide for 45 minutes.[9] The research conducted by Cooley and Burger and Bailey and Swift stated that the use of home bleaching agents had increased the surface roughness of the composite resin.[16,17]

Two things cause the increasing value of the surface roughness of the composite resin applied by the bleaching agents. First, the breakdown of the matrix bonds due to the free radicals produced by hydrogen peroxide, and second, the breaking of siloxane bonds due to hydrogen ions.[13]

Hydrogen peroxide is a powerful oxidizer that can decompose into free radicals. Free radical products have unpaired and unstable electrons bound to other organic molecules for stabilization.[4] The free radicals break the cyclic carbon bonds in the composite resin matrix. This reaction is similar to the free radical reaction that breaks the cyclic carbon bonds in the tooth enamel. This cyclic chain will turn into a double bond which will then break again into a single bond. This process will continue until full oxidation was completed. This reaction caused the composite resin matrix bond become weak and degraded.[8]

Another factor is the breaking of the siloxane bonds due to hydrogen ions. Hydrogen

peroxide contains high hydrogen ions with higher bonding tendencies. Termination of siloxane bonds resulting in degradation of the composite resins by shortening the polymer chain into oligomers, then into a monomer chain. The breaking of the siloxane bond causes the matrix particles and filler material released from the resin surface, thus the surface becomes uneven. The uneven surface of the composite resin caused the roughness of the composite resin surface.[8]

According to Shethri's research, the increasing roughness value of the composite resin surface after the application of the teeth whitening agent was influenced by the type of the composite restorative materials and the whitening agent application duration.[18] Also, the hydrogen peroxide concentration and the pH value of the teeth whitening agent used may also affect the side effects of the restorative materials.

Changes in the roughness value of the composite restorative material surface also depend on the teeth whitening technique used. Several studies have suggested the effect of teeth whitening on the surface roughness value of composite restorative materials, using in-office and home bleaching techniques. The results also varied depends on the teeth whitening technique used.

According to the research conducted by Atali and Topbasi, there was a significant difference in the surface roughness value between the Filtek Silorane composite resin and the Nanohybrid Grandio composite resin after application of 38% Opalescence office bleaching. Hafez had stated that there was a significant increase in the composite resin surface roughness after application of Luma White-plus & Opalescence Boost (Beyond) tooth whitening agent towards the microfilm and micro-hybrid.[19]

The above description suggested that the roughness of the composite resin surface was one of the side effects of the use of the teeth whitening. The results showed that there were differences in the surface roughness value of the methacrylate and silorane based composite resin applied by 40% hydrogen peroxide for 20 minutes. This result may also influenced by the hydrogen peroxide concentration, the type of the composite restoration materials, and the particle size of the composite resin filler material.

CONCLUSION

There was a surface roughness difference of the methacrylate-based and silorane-based composite resin after the application of 40% hydrogen peroxide. The surface roughness value of the silorane-based composite resin was higher than the methacrylate-based.

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