

Differences of methacrylate and silorane based composite resins surface hardness after 40% hydrogen peroxide application

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ABSTRACT

Composite restoration is frequently found on teeth before doing any bleaching treatment. Hydrogen peroxide is a bleaching agent which enable transition to one of the composite physical properties. The aim of this research was to observe the difference of surface hardness between methacrylate and silorane based composite resin after application of 40% hydrogen peroxide. This true experiment involved 36 specimens from two different disc-shaped methacrylate and silorane based composite resins, with 18 specimens methacrylate and 18 silorane. Every specimen groups were immersed in artificial saliva solution and divided into two groups; the first group consisted of 9 specimens of control which were tested directly using microvickers hardness tester and another group consisted of 9 specimens which had been added by 40% hydrogen peroxide for hardness test. The result showed the different surface hardness average value of metachrylate and silorane based composite resin after application of 40% hydrogen peroxide. The surface hardness of methacrylate and silorane based composite resins was 41.8 VHN and 33.7 VHN ($p>0.05$) with t-test, respectively. From this study concluded that there was no significant difference between methacrylate and silorane based composite resins after 40% hydrogen peroxide application.

Keywords: 40% hydrogen peroxide, surface hardness, methacrylate, silorane

INTRODUCTION

Interest in the field of esthetic dentistry has become commonplace in today's world and attracts the attention of all ages.¹ It is proved by the many publications of dentistry journals that deal specifically with this issue. In Indonesia, in line with increasingly evolving thoughts and information, people's insights are increasingly open to aesthetic dentistry. This has become a hot topic in society and makes people pay more

attention to aesthetics so that care has been to the stage of care that can beautify the appearance.²

The teeth whitening technique is included in esthetic dentistry because it makes the teeth brighter and embellishes one's appearance. This bleaching technique was first used in the late 1870,³ and continues to be used today. The teeth whitening technique can be classified into bleaching on vital and non-vital teeth and when viewed from the technique consisting of in-office bleaching and home bleaching.

Over the last few years vital home teeth whitening techniques have attracted both patients and dentists because of their success rate, and ease of use. But recently, in-office teeth whitening products that use high concentrations of hydrogen peroxide were re-introduced. The latter procedure, one of which uses 30% to 40% hydrogen peroxide, has the advantage of being fully within the dentist's control and is more effective because of the faster bleaching process.⁴

Bleaching techniques are generally applied to six anterior teeth and may be found in composite fillings of classes I, III, IV, V, and veins on those teeth.⁴ As with bleaching techniques, restorations with composite resins are also included into esthetic dentistry, since it can be used to restore lost tooth structure and modify contours and colors that resemble original teeth so as to improve one's appearance.⁵

The composite consists of four main components, namely the maktriks which are organic components, fillers or the so-called fillers which are an inorganic components, coupling agents for embedding matrices and fillers and system of accelerators.^{6,5} Dental restorative materials have improved over the last decade, including composite restorations.⁷ Key strategies have been carried out since 1950 by composite product companies to reduce leakage or shrinkage in composite restorations by increasing filler load, and efforts to improve physical properties have focused on developing monomers that are organic components contained in the matrix and new technology of filler.⁸ The development of this monomer is silorane. This silorane-based composite has a "ring-opening" monomer which at the time of polymerization of this ring-shaped monomer will open, elongate and attach to each other. The result is a significantly smaller shrinkage volume than a methacrylate-based composite. Methacrylate is also a monomer contained in a composite matrix mostly used in composite resins.⁹ Metallized composites of methacrylate have linearly shaped monomers, which when polymerization extends and attaches to each other, resulting in reduced volume resulting in increase in depreciation.⁹

Many studies have reported on the effect of teeth whitening on composite restorations. Obtained a decrease in hardness in flowable

composites after a teeth whitening technique.¹⁰ Several studies have also been conducted to compare the physical properties of metallic and silorane based composites, one of which is comparing the value of surface hardness of composite restorations. Decrease in hardness or softening is one of the important properties of a restoration of physical properties¹¹ and these physical properties can help predict the vulnerability of restorative materials to damage during mastication.¹²

The purpose of this study was to observe the difference of surface hardness between methacrylate and silorane based composite resin after application of 40% hydrogen peroxide in-vitro.

METHODS

The type of research conducted was pure experimental in-vitro.

The study population was metallic and silorane based composite resin. The samples were 36 composite resin specimens consisting of 18 methacrylic-based specimens and 18 silorane-based specimens. Determination of the size of this sample is based on the formula to test the difference of two average with the formula of $n = 2S^2 (Z_{\alpha} + Z_{\beta})^2 / d^2$.

By choosing 95% as the confidence level ($Z_{\alpha} = 1.96$) and the power test of 80% ($Z_{\beta} = 0.84$) and deviation standard size (S) and d = magnitude of average difference of surface hardness of resin obtained from Wattanapayungkul and Yap which used the largest Sd ($S = 4.68$) and $d = 3$. Based on the formula of the sample size is obtained $n = 18$ per group. The research unit was a composite Vickers Hardness Number (VHN) measured on Vickers Microhardness Tester.

To support this research, several tools and materials used in the manufacture of specimens, application of teeth whitening, and measurement of surface hardness of the material. The tools needed in the research were light curing unit, composite mold, timing, tweezers, composite restoration equipment, measuring cups, composite resin mold, Vickers Microhardness Tester, Ultrasonic cleaner, Glass Lab. Materials required in the study were methacrylate-based composite

resin of Filtek® Z350, silorane-based composite resin of Filtek® P90, 40% Hydrogen Peroxide, distilled water, Mylar® matrix, absorbent paper, and artificial saliva.



Figure 1. Tools and materials

The working procedure of the research was the manufacture of specimens (Composite resins prepared according to the instructions of the plant were inserted into a 6 mm diameter disk-shaped aluminum discs with the thickness of 3 mm based on mylar matrix, composite resin cavities covered with mylar matrix, composite resin polymerized by light-unit unit for 20 seconds, then composite resin specimens divided into 2 groups, 18 specimens each). The application of hydrogen peroxide (Control group: immerse the specimens in artificial saliva for 24 hours, remove and then rinse the specimens with water, cleaning using ultrasonic cleaner for 5 minutes, dry the specimens. Treatment group: immerse the specimens on artificial saliva for 24 hours, lift then rinse the specimens with water, purge using ultrasonic cleaner for 5 minutes, dry the specimens, apply hydrogen peroxide 40% according to the manufacturer's instructions on the surface of the composite resin, wait for 20 minutes, then rinse the specimens with water, continue cleaning with ultrasonic cleaner for 5 minutes and dry).

Surface of the tested specimen was dried with absorbent paper. Then measured hardness values of composite restorative materials by using Vickers Microhardness Tester. The procedure of using the tool includes placing the sample on the preparatory table, adjusting the focus by raising or lowering the elevating handle, indenting it by

placing the indenter just above the sample for 15 seconds with 0.1 kg load by turning the turret, press start (wait until the light turns off), rotate the turret back to magnification first, measure d_1 (diagonal length 1) by rotating the left knobs and then rotate the right knobs, press d-input, then measure d_2 , then get d_1 , d_2 , and hardness Vickers Number, lastly do three test in a different place.

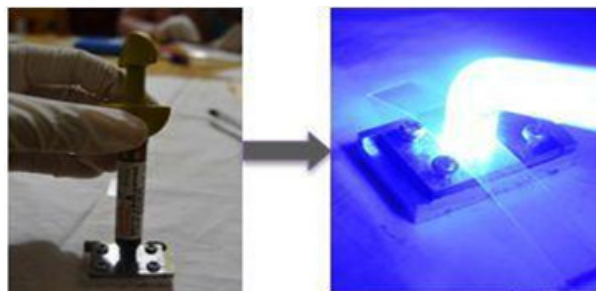


Figure 2. Specimens manufacturing

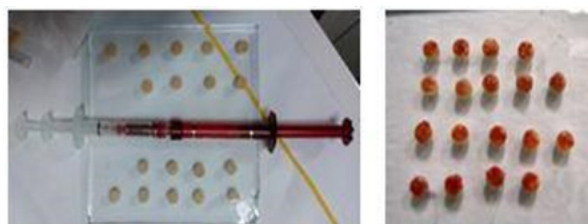


Figure 3. Application of 40% hydrogen peroxide

RESULTS

The study was conducted on 36 samples, with 18 groups of methacrylate and 18 groups of silorane, and subdivided into 9 control groups and 9 treatment groups. Each group was immersed in artificial saliva for 24 hours, then in the direct control group tested for hardness and in the treatment group was applied 40% hydrogen peroxide for 20 minutes then tested the hardness. Hardness testing was performed on one side of the specimen using a microvickers hardness tester. The results showed that each sample experienced a difference in hardness value with a smaller trend in the application of 40% hydrogen peroxide.

Table 1 showed the measured values on 18 specimens of methacrylate-based composite resins with mean of hardness in the artificial saliva of 44.1 VHN and experienced a difference in hardness value with a smaller tendency in 40% hydrogen peroxide application of 41.8 VHN.

Table 1. Measurement on methacrylate group

Composite specimen	Artificial saliva	40% Hydrogen Peroxide
1	46.5	37.7
2	42.4	45.6
3	48.9	42.5
4	43.8	41.1
5	40.8	38.7
6	49.3	44.4
7	42	46.7
8	44.5	43.7
9	38.4	35.5
Average	44.1	41.8

Table 2. Measurement on silorane group

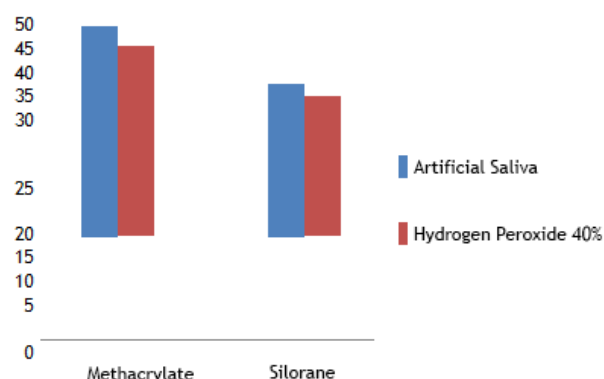
Composite specimen	Artificial saliva	40% Hydrogen Peroxide
1	32.5	34.5
2	37.6	35.6
3	36.7	33.7
4	32.3	39.4
5	34.5	32
6	32	39.6
7	33.7	28.1
8	32.7	32.9
9	33.3	27.8
Average	33,9	33,7

Table 2 showed the value of measurements on 18 specimens of silorane-based composite resins with mean of hardness in artificial saliva of 33.9 VHN and experienced different hardness values with less tendency in 40% hydrogen peroxide applications of 33.7 VHN.

Table 3. Results Mean Value of Hardness Resin Composite Based Methacrylate and Silorane in Artificial Saliva and Applications of Hydrogen Peroxide 40%

Specimen	VHN average	Std. dev.
Methacrylate-Artificial saliva	44.1	3.6
Methacrylate-Hydrogen Peroxide 40%	41.8	3.8
Silorane-Artificial saliva	33.9	2.0
Silorane-Hydrogen Peroxide 40%	33.7	4.2

Table 3 showed the mean comparison values of methacrylic and silorane based resins in artificial saliva and 40% hydrogen peroxide applications. It was found that the mean difference of metacrylic composite resin hardness in artificial saliva and hydrogen peroxide application was 40% greater than that of silorane composite resin.

**Figure 4.** Average value of surface hardness value of methacrylate and silorane-based composites.

Based on Figure 4 the tendency of hardness values to be smaller is greatest in the methacrylate-based composite resin which was applied by 40% hydrogen peroxide. To determine the significance of the statistical test of the difference in mean of hardness between artificial saliva application and hydrogen peroxide, the first step is to test the data normality based on Shapiro Wilk test, the result was shown in Table 4.

Based on the normality test the average surface hardness data of both base material and treatment showed insignificant results ($p > 0.05$), showed that the data came from normal distributed population, so for the purposes of different test analysis, used parametric statistic with T test.

Based on Table 5, the result of statistical test using T test shows that the difference of methacrylate and silorane hardness values in treatment with artificial saliva and hydrogen peroxide 40% is not significant, for methacrylate based material $p = 0,209$ and silorane base material $p = 0,905$. However, the difference of methacrylate and silorane hardness values with artificial saliva application was statistically significant with p value < 0.001 ; and with a hydrogen peroxide application of 40% with a value of $p = 0.001$. It appeared that the use of silorane base material in both artificial saliva treatment and 40% hydrogen

peroxide were having a mean surface hardness of the resin lower when compared with the use of silorane base material.

Based on the statistical test results,

there were no significant difference between methacrylate-artificial saliva, methacrylate-hydrogen peroxide 40%, silorane-artificial saliva, and silorane-hydrogen peroxide 40%.

Table 4. Normality test result of surface hardness of methacrylate and silorane based composites

Surface hardness (VHN)	Statistical Measurement			Normality data test* (p-value)
		SD	Range	
Methacrylate-Artificial saliva	44.1	3.6	38.4-49.3	0.820
Methacrylate-Hydrogen peroxide 40%	41.8	3.8	35.5-46.7	0.766
Silorane-Artificial saliva	33.9	2.0	32.0-37.6	0.082
Silorane-Hydrogen peroxide 40%	33.7	4.2	27.8-39.6	0.505

Based on Shapiro-Wilk test

Table 5. Comparison result of the surface hardness of methacrylate and silorane based composites

Surface hardness	Treatment		t-test	p-value
	Artificial saliva	Hydrogen peroxide 40%		
Methacrylate \bar{X}_{SD}	44.1(3.6)	41.8(3.8)	1.308	0.209
Silorane \bar{X}_{SD}	33.9(2.6)	33.7(4.2)	0.122	0.905
t-test	7.311 p<0.001	4.251 p=0.001		

Notes: p<0.05 significant; p>0.05 not significant

DISCUSSION

In a study of 18 specimens of methacrylate-based composite resin and 18 silorane specimens there was a change in the value of surface hardness with a smaller trend after the insignificant application of hydrogen peroxide 40%. In the teeth whitening process, H_2O_2 will produce $HO_2\cdot$ (perhydroxyl) which is a strong free radical and $O_2\cdot$ as a weak free radical. Once $HO_2\cdot$ is formed in large quantities, this free radical will react with the unsaturated bonds of the electron bond. This leads to interference in electron conjugation and changes in energy absorption in organic molecules, in addition to changes in the molecular weight of the organic matter of the tooth that reflects the discolorizing specific light waves in the material with a lower molecular weight and the reduced molecules reflecting light, thus forming molecules organic yag with a lighter color.¹³

In composite restorations, Bailey in 1992, and Hannig in 2006 explained that tooth whitening agents can reduce composite hardness because hydrogen peroxide oxidizes and generates free

radicals.^{15,16} This hydrogen peroxide breaks down into H^+ ions which are unstable free radicals. The free radicals formed will interact with the composite organic molecule that is the matrix and break the cyclic carbon bonds found in Bis-GMA.^{14,16,15,17} The reaction occurring in this composite is similar to that occurring in the tooth enamel during the teeth whitening process. The double bond of carbon in the cyclic chain will be broken into a single chain. This process continues until there is complete oxidation. This condition causes the cyclic bis-GMA to weaken and degrade so that the composite hardness will decrease.^{18,15,19} Besides attacking the carbon chain bonds on the resin matrix, free radicals also attack the bond on the coupling agent. Peryhydroxyl which is a weak acid will break the bond of siloxane into silanol bond. Breaking of the siloxane bond between the coupling agent and the filler will lead to the release of the filler particles and a decrease in the hardness of the surface of the composite resin. This was supported by research that says that the chemical process of teeth whitening will accelerate the degradation of hydrolytic resin

composite.²⁰

In Table 3, the mean values of hardness of silicone-based composite resin were smaller than those of methacrylate-based composite resin, supported by the research of Lien and Vandawalle in 2009 on the physical properties of silorane-based composite resins and the research of Ilie and Hickel investigated the mechanical properties of the silorane-based macro, micro, and nano resins with the resultant surface hardness of silorane-based resins lower when compared with methacrylate.

Table 5 showed the difference in the value of hardness with smaller inclinations greater in methacrylate than silorane. In the methacrylate base material this is due to the bis-GMA cyclic degradation mechanism in the methacrylate-based composite matrix by hydrogen peroxide, but no literature has yet been made about the effect of the hydrogen peroxide on the silorane matrix. The resulting difference in hardness values in artificial saliva applications and the small application of hydrogen peroxide to the silorane matrix may have a stronger matrix-filler bond than the methacrylate matrix-filler bond.

Several studies have suggested the effect of in-office bleaching on surface hardness of new composite resins.^{15,21,4} Polydorou in 2006 reported that the influence tooth whitening on surface texture depends on the material and time.²² Other research claimed that the teeth whitening agent not only softens the surface of the material restoration but also softens the deeper layers.¹⁵

CONCLUSION

From this study concluded that there was no significant difference between methacrylate and silorane based composite resins after 40% hydrogen peroxide application.

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