Evaluation of Light Curing Distance and Mylar Strips Color on Surface Hardness of Two Different Dental Composite Resins

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Abstract: *Introduction:* Hardness is one of the basic properties of dental materials, specially composite resins which is relevant to their polymerization. The aim of this study was to evaluate the effect of light curing distance and the color of clear Mylar strips on surface hardness of Silorane-based (SCR) and Methacrylate-based composite resins (MCR).

Materials and methods: 40 samples of MCRs (Filtek Z250) and SCRs (Filtek P90) were prepared in size of 5 mm×2 mm (80 samples in total). The samples divided into 8 groups (10 samples in each one) based on the color of clear Mylar strips (white or blue) and distance from light curing source (0 mm or 2 mm). All the samples cured for 40 second and stored in incubator for 24 hours in 37°C temperature. Surface hardness test was done by Vickers test machine and the collected data were analyzed by one-way ANOVA and paired T-test by using SPSS software version 13 at significant level of 0.05.

Results: MCRs cured with blue Mylar strips from 0 mm distance had the highest (114.5 kg/mm^2) and SCRs cured with white Mylar strips from 2 mm distance had the lowest (42.2 kg/mm^2) mean of surface hardness. Also, the results of comparison among SCRs and MCRs showed significant differences among all groups (all P values <0.01).

Conclusion: The hardness decreased as the distance increased and the blue Mylar strips provided higher hardness than clear ones. Also, Filtek Z250 showed higher hardness compared to Filtek P90.

Keywords: Light curing, methacrylate-based composite resin, silorane-based composite resins, vickers hardness.

INTRODUCTION

The use of composite resins has opened a new approach in dentistry as it can fulfill the expectations and requirements in the oral environment with proper function and special esthetics [1].

In order to modify the properties of composites, structural changes were executed. Silorane-based composite resins (SCR) introduced alongside with conventional Methacrylate-based composite resins (MCR) as a new composite resin to decrease the polymerization shrinkage [2].

Surface hardness is one of the important characteristics of composite resins which can affect the clinical success rate of restorations. Nowadays various types of composite resins are available based on different fillers, which provides different hardness of composite resins too [3]. The distance of composite resins from the light curing source is another factor that influences the hardness. It is proved that the hardness is higher in lower curing distances [4-8].

In one study, Caldes *et al*. evaluated the influence of curing distance on the knoop Hardness. They examined three different distances (0, 6 and 12 mm) and the result showed that the hardness of the resin composite decreased as the light tip distance increased [9].

In another study, de Araújo *et al.* investigated the effect of light curing method, composite resin shade and depth of curing on their microhardness. They concluded that light curing method including variations of time, depth of curing and the composite resin shade influenced their microhardness [10].

It is assumed that shade is an important factor that can affect the mechanical properties of light-curing polymerization [11] and several studies stated that darker shades made

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Table 1. The mean surface hardness (Kg/mm^2) in different groups of study.

Groups	Mean (Sd)	Lower Level	Upper Level
M1	114.50(17.60)	83.50	147.80
M2	95.10(13.56)	78.20	128.80
M3	99.75(13.90)	70.70	135.50
M4	92.50(10.13)	97.30	120.60
S1	67.17(7.51)	57.20	94.60
S2	54.89(8.46)	42.30	77.20
S3	65.40(4.28)	58.50	71.50
S4	42.17(6.25)	25.80	50.20

higher hardness [1, 12]. Also, the resemblance in color between the intermediate materials (Mylar strips) and curing light may affect the polymerization procedure, thus some manufacturers produce the Mylar strips in blue.

As there were no previous study based on effect of Mylar strip's color on polymerization, the aim of this study was to evaluate the effect of light curing distance and the color of clear Mylar strips on surface hardness of two different composite resins (SCR and MCR).

MATERIALS AND METHODOLOGY

In this analytical-observational in vitro study, a hard polymeric disk-shaped mold (washer) in the size of 5 mm×2 mm was placed on a slab for preparing composite resin disks. Then 40 samples of Methacrylate-based (Filtek Z250, 3M ESPE dental product, USA) and Silorane-based composite resins (Filtek P90, 3M ESPE dental product, USA) were packed in the mold (80 samples in total). The samples divided into 8 groups (10 samples in each one), based on the color of clear Mylar strips and distance from light curing source, in the following procedure:

Group M1: MCRs cured from 0mm distance with using clear blue Mylar strips (HaweBlue Striproll, Switzerland).

Group M2: MCRs cured from 2 mm distance with using clear blue Mylar strips.

Group M3: MCRs cured from 0mm distance with using clear white Mylar strips (100 universal Strips, Alfred Becht Gmbh,D Offenburg, Germany).

Group M4: MCRs cured from 2 mm distance with using clear white Mylar strips.

Group S1: SCRs cured from 0 mm distance with using clear blue Mylar strips.

Group S2: SCRs cured from 2 mm distance with using clear blue Mylar strips.

Group S3: SCRs cured from 0 mm distance with using clear white Mylar strips.

Group S4: SCRs cured from 2 mm distance with using clear white Mylar strips.

Also, another mold was placed on the samples for providing 2mm distance in mentioned designed groups. All the samples were cured by LED light curing unit (Litex 695C, Dentamerica, Taiwan) with the same time (40 seconds) and output (checked 1200 mw/cm^2) for all the groups. All the samples stored in incubator for 24 hours in 37°C temperature. Finally the samples were subjected to surface hardness test by Vickers test machine (Fretz, Germany) based on indentation method. The test was prepared 3 times for each sample with 10×10^{-3} kg/mm^2 in 10 seconds.

The collected data were analyzed by one-way ANOVA and paired T-test (for comparing groups, 2 by 2) with using SPSS software version 13 at significant level of 0.05.

RESULTS

Table **1** represents the mean surface hardness of the groups based on curing distance and color of clear Mylar strips. As the results showed, the group M1 had the highest (114.5 kg/mm^2) and group S4 had the lowest (42.2 kg/mm^2) mean of surface hardness. Also, the results of one-way ANOVA demonstrated that the mean surface hardness showed significant differences among all the groups(p value<0.05).

Table **2** represents the comparisons of mean surface hardness among all the groups based on paired T-test. The comparison among MCRs clarified that group M1 had significant differences with groups M2, M3 and M4 (all P values<0.05). The mean surface hardness was higher in M3 than M4 despite of no significant differences (P value=0.2). The comparison among SCRs showed significant differences among all the groups (all P values<0.05) except between S1 and S3 (P value>0.05). Also, the results of comparison among SCRs and MCRs showed significant differences among all groups (all P values<0.01).

DISCUSSION

Based on the results, curing from 0mm distance (M1, S1 and S3) made higher surface hardness than curing from 2mm distance (M2, S2 and S4) (all P values<0.05), specially in SCRs, which indicates that distance have negative impact on the final surface hardness.

Table 2. Two by two comparison by paired T-test between different groups.

Groups	P value	Groups	P value	Groups	P value
M1 and M2	<0.01	*S1 and S2*	<0.01	*M1 and S1*	<0.01
M1 and M3	0.02	*S1 and S3*	>0.05	*M2 and S2*	<0.01
M1 and M4	<0.01	*S1 and S4*	<0.01	*M3 and S3*	<0.01
M2 and M3	>0.05	*S2 and S3*	<0.01	*M4 and S4*	<0.01
M2 and M4	>0.05	*S2 and S4*	<0.01		
M3 and M4	0.2	*S3 and S4*	<0.01		

In 2009, Aguiar *et al*. conducted a study about the effect of curing distance and layer thickness on composite resins' microhardness. They concluded that the microhardness decreased as the curing distance and layer thickness increased [8]. In another study, Thome *et al*. observed the impact of curing distance (in 0, 6 and 12 mm), shade and filler size on final hardness of composite resins. Their final result showed that curing distance and composite resin's color had significant effect on final microhardness [7]. The result of present study confirms the findings of two mentioned studies. Also, many other studies reported the negative impact of curing distance too [5, 9, 13].

Based on physics, when a monochromatic light passes through a clear object with the same color, the light intensity increases which cause higher polymerization and hardness in composite resins. The blue Mylar strips (M1) had significant effect in comparison with white ones (M3) in 0mm distance (P value=0.02), but no significant difference was found when the distance was 2 mm (group M2 and M4) (P value>0.05). The results were reverse in SCRs meaning that, significant effect was found between groups S2 and S4 (2 mm distance) and the blue Mylar strips made higher surface hardness (P value<0.01). One study stated that the highest degree of conversion and Knoop hardness happened at 2 mm depth in SCRs [14]. The other reason might be due to structure and polymerization characteristics of these two types of composite resins but no other studies have been surveyed the effect of clear Mylar strips' color on polymerization since now.

As Table **2** illustrates, higher hardness was found in MCR groups (M1, M2,M3 and M4) when compared to similar groups in SCRs (S1, S2, S3 and S4) (all P values<0.01). This might be due to different polymerizations of these composite resins. It seems that cross link reaction in MCRs results in higher rates of polymerization and lower amounts of free monomers than ring opening reaction in SCRs. Also, Camphorquinone of initiators in MCRs, absorb higher ranges of LED light (maximum 486 nm) which is produced by LED light source. Adding diphenyl iodonium or triphenyl sulfonium salts to amin system, which is used in MCRs, not only reduces the transferring of photon-wasting electrons and recombination reactions, but also provides a recycling path for consumed photosensitizer and increases the rates of polymerization effectively [15-18]. In another view, SCRs are polymerized by cationic polymerization systems, which is different from the radical polymerization of MCRs [19]. Maybe using LED light source, which contains multilayer of triphenylene, can provide harder and deeper curing in SCRs due to deep blue light(in range of 436-456 nm) [15, 20].

In one study, Bechtold *et al.* evaluated Knoop hardness and polymerization depth in Filtek P60 composite (MCR) and Filtek P90 composite (SCR) by using three different light curing techniques (Occlusal; transdental; transdental+ occlusal) in class II restorations. They claimed that SCRs showed lower hardness than MCRs significantly [21].

In another study, Kusgoz *et al.* compared the depth of curing, hardness, degree of conversion and cervical sealing ability in SCRs and MCRs. Their results revealed that the degree of conversion, hardness and curing depth in SCRs were significantly lower than MCRs [22]. Besides the results of present study, two other studies [23, 24] confirmed this fact too.

CONCLUSION

With considering limitations of invitro studies, it can be concluded that:

1. The hardness of both types of composite decreased as the distance increased.
2. Blue Mylar strips provided higher hardness than white ones, depending on the composite type and light source distances.
3. The methacrylate-base composite resin (Filtek Z250) showed higher hardness than Silorane-based composite resin (Filtek P90).

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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REFERENCES

[1] Briso AL, Fedel TM, Pereira Sde M, Mauro SJ, Sundfeld RH, Sundefeld ML. Influence of light curing source on microhardness of composite resins of different shades. J Appl Oral Sci 2006; 14(1): 10-5.

[2] Sakaguchi RL, Powers JM. Craig's restorative dental materials. Chapter 9, 3rd ed. Elsevier Mosby 2012.

[3] Friedman J. Care and maintenance of dental curing lights. Dent Today 1991; 10(1): 40-1.
[4] Rode KM, Kawano Y, Turbino ML. Evaluation of curing light distance on resin composite microhardness and polymerization. Oper Dent 2007; 32(6): 571-8.
[5] Aguiar FH, Lazzari CR, Lima DA, Ambrosano GM, Lovadino JR. Effect of light curing tip distance and resin shade on microhardness of a hybrid resin composite. Braz Oral Res 2005; 19(4):302-6.
[6] Pires JA, Cvitko E, Denehy GE, Swift EJ Jr. Effects of curing tip distance on light intensity and composite resin microhardness. Quintessence Int 1993; 24(7): 517-21.
[7] Thome T, Steagall W Jr., Tachibana A, Braga SR, Turbino ML. Influence of the distance of the curing light source and composite shade on hardness of two composites. J Appl Oral Sci 2007; 15(6): 486-91.
[8] Aguiar FH, Andrade KR, Leite Lima DA, Ambrosano GM, Lovadino JR. Influence of light curing and sample thickness on microhardness of a composite resin. Clin Cosmet Investig Dent 2009; 1: 21-5.
[9] Caldas DB, de Almeida JB, Correr-Sobrinho L, Sinhoreti MA, Consani S. Influence of curing tip distance on resin composite Knoop hardness number, using three different light curing units. Oper Dent 2003; 28(3):315-20.
[10] de Araujo CS, Schein MT, Zanchi CH, Rodrigues SA Jr., Demarco FF. Composite resin microhardness: the influence of light curing method, composite shade, and depth of cure. J Contemp Dent Pract 2008; 9(4): 43-50.
[11] Jeong TS, Kang HS, Kim SK, Kim S, Kim HI, Kwon YH. The effect of resin shades on microhardness, polymerization shrinkage, and color change of dental composite resins. Dent Mater 2009; 28(4): 438-45.
[12] El-Askary FS, El-Korashy DI. Influence of shade and light-curing distance on the degree of conversion and flexural strength of a dual-cure core build-up resin composite. Am J Dent 2012; 25(2): 97-102.
[13] Leloup G, Holvoet PE, Bebelman S, Devaux J. Raman scattering determination of the depth of cure of light-activated composites: influence of different clinically relevant parameters. J Oral Rehabil 2002; 29(6): 510-5.
[14] Torres S, Silva G, Maria D, Campos W, Magalhaes C, Moreira A. Degree of conversion and hardness of a silorane-based composite resin: effect of light-curing unit and depth,Oper Dent 2014; 39(3): E137-46.
[15] Cramer NB, Stansbury JW, Bowman CN. Recent advances and developments in composite dental restorative materials. J Dent Res 2011; 90(4): 402-16.
[16] Shin HD, Rawls HR. Degree of conversion and color stability of the light curing resin with new photoinitiator systems. Dent Mater 2009; 25(8): 1030-8.
[17] Kim D, Scarnton A. The role of diphenyl iodonium salt (DPI) in three-component photoinitiator systems containing methylene blue (MB) and an electron donor. J Polym Sci Part A: Polym Chem 2004; 42(23): 5863-71.
[18] Lalevee J, El-Roz M, Allonas X, Fouassier JP. Free-radical-promoted cationic photopolymerization under visible light in aerated media: new and highly efficient silane-containing initiating systems. J Polym Sci Part A: Polym Chem 2008; 46(6): 2008-14.
[19] Hamano N, Ino S, Fukuyama T, Hickel R, Kunzelmann KH. Repair of silorane-based composites: microtensile bond strength of silorane-based composites repaired with methacrylate-based composites. Dent Mater 2013; 32(5): 695-701.
[20] Wettach H, Jester SS, Colsmann A, Lemmer U. Deep blue light-emitting diods based on triphelene. Synthetic Metals 2010; 60(7-8): 691-700.
[21] Bechtold J, Dos Santos PJ, Anido-Anido A, Di Hipolito V, Alonso RC, D'Alpino PH. Hardness, polymerization depth and internal adaptation of Class II silorane composite restorations as a function of polymerization protocol. Eur J Dent 2012; 6(2): 133-40.
[22] Kusgoz A, Ulker M, Yesilyurt C, Yoldas OH, Ozil M, Tanriver M. Silorane-based composite: depth of cure, surface hardness, degree of conversion and cervical microleakage in Class II cavities. J Esthet Restor Dent 2011; 23(5): 324-35.
[23] Porto IC, de Aguiar FH, Brandt WC, Liporoni PC. Mechanical and physical properties of silorane and methacrylate-based composites. J Dent 2013; 41(8): 732-9.
[24] Brandt WC, Lacerda RF, Souza-Junior EJ, Sinhoreti MA. Effect of photoactivation mode on the hardness and bond strength of methacrylate- and Silorane monomer-based composites. J Adhes Dent 2013; 15(1): 33-9.

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