



Effect of Irradiation Distance of LED on Bulk-Fill

Composite Resin Hardness

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Abstract

Introduction: Bulk-fill composite is a restorative material with the advantage of 4 mm thickness application into the cavity and good modulus of elasticity similar to natural teeth. One of the important aspect in composite restoration is polymerization which is a formation of polymer from monomers. One way to achieve a high degree of polymerization is to use Light Emitting Diode (LED) irradiation, which will increase the hardness of the composite resin. **Objective:** The purpose of this study was to determine the effect of distance between the LED tip with bulk-fill composite surface on the hardness of composite. **Methods:** Fifteen samples were divided into three groups with irradiation distance of 0 mm, 5 mm, and 9 mm respectively. Samples were made in a cylindrical shape with 6 mm of diameter and 4 mm of height then irradiated with LED for 10 seconds. The samples then immersed in distilled water at 37° for 24 hours. Hardness test was carried out on three different points at the top and bottom each side using Vickers hardness test. Data was analyzed with Shapiro-Wilk and One Way ANOVA. **Results:** The highest hardness value was obtained in the group with an irradiation distance of 0 mm, while the lowest was in the group with irradiation distance of 9cm, both on the top and bottom surfaces. Increasing the distance between the tip of light curing unit and the composite surface resulted in a significant reduction in the hardness of the composite. **Conclusion:** There were significant differences in the hardness value of bulk-fill composite in all distance group.

Keywords: Bulk-fill composite resin; Hardness; Irradiation distance; Vickers hardness tester

Introduction

Composite resin is a dental restorative material that known since 1962.¹ The advancement of composite resin was showed by the introduction of bulk-fill composite resin in 2010. Bulk-fill composite resins are materials with the advantages of application up to 4 mm into the cavity and possessing mechanical properties similar to the structure of natural teeth.² Ivocerin is a benzoyl germanium derivative added to the composition of the bulk-fill composite resin acted as an initiator in the polymerization process. A study suggested that Ivocerin is a better initiator than champroquinone so that bulk-fill composite resin has good mechanical properties.³



One of the mechanical properties of composite resin is hardness. Hardness properties could be calculated based on both depth and area of indentation. Vickers hardness measurement (VHN) is one of the most important method to measure surface hardness of composite, to compare different types of composites.⁴ A needle with a pyramid-shaped diamond was used for the test with VHN measurement unit.⁵ The hardness ratio is a comparison of the hardness values between the top and bottom surface hardness. Optimal polymerization of material could be seen from the minimum hardness ratio of 80%.⁶

A study conducted by Isil Cekic-Nagas and Thai Thome reported that the tip distance of the light source affects the mechanical properties of the composite.^{7,8} Researchers proved that minimal distance of irradiation on the conventional composite surface has the highest mechanical properties. However, minimal distance was difficult to apply when irradiating posterior teeth.^{1,7,8} The depth of the cavity, particularly in deep Class II restoration, does not allow the tip of the light-curing unit to be as close as possible to the surface of the bottom layer that is applied with incremental technique.

In the past few years, bulk-fill resin-based composite resins have increasingly been used. Unlike the conventional composite, this type of material can be placed as a single or deeper increment, with depth between 4 to 10 mm. The manufacturer used “Ivocerin” a highly reactive photoinitiator that can polymerize the material in depth.⁹ The purpose of this study was to determine the effect of the distance between LED tip with bulk-fill composite surface on the bulk-fill composite hardness using Vickers hardness tester.

Methods

This present study was a true experimental study that used Tetric N-Ceram Bulk-fill composite resin to make samples of 4 mm in height and 6 mm in diameter. The specimens were irradiated using Light Emitting Diode (LED) and divided into three groups with curing distances of 0 mm, 5 mm, and, 9 mm respectively. The distance between the light-curing unit tip and the composite resin surface is adjusted using a plastic ring.

The specimens were immersed into a glass containing distilled water in a water bath for 24 hours at 37°C. The Vickers hardness was measured on the top and the bottom surfaces of the specimens using a Digital Micro Vickers hardness tester Micromet II Buehler with a load of 50 grams, loading time of 15 seconds, and a distance of 0,1 mm each point. The value of hardness of each sample of bulk-fill composite resin is in Vickers hardness number (VHN).

Result

In all groups, there was a similar trend where the average hardness value of the specimens on the upper surface was higher than the bottom. The hardness mean values of specimens photo-activated with curing distance 0 mm are the highest, while the lowest value is the specimens of 9 mm as illustrated in Table 1 and Figure 1.

Table 1. Hardness mean value of bulk-fill composite with curing distance 0, 5, 9 mm

Curing distance	Hardness value on top surface (VHN)	Hardness value on bottom surface (VHN)	Hardness ratio (%)
0 mm	95,32	81,58	85,6
5 mm	74,22	49,84	67,2
9 mm	49,58	23,00	46,4

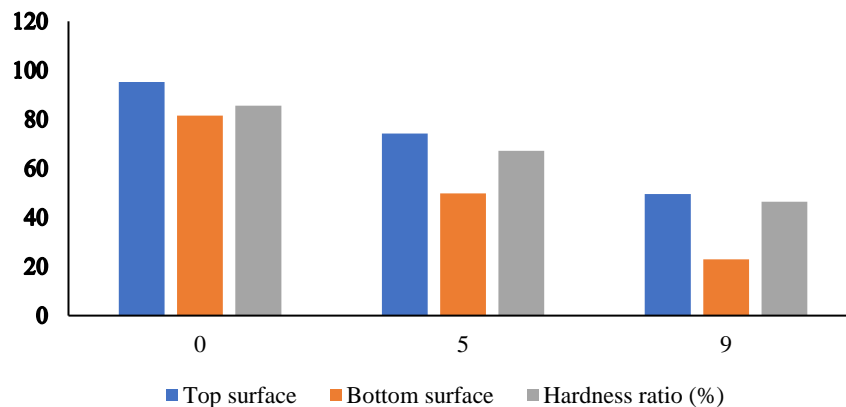


Figure 1. Hardness mean values of Bulk-fill composite resin with different curing distance

The mean value of hardness then were analyzed for normality test using Shapiro-Wilk Test. A follow-up test using the One Way ANOVA was carried out to determine the effect of the curing distance on the hardness of the bulk-fill composite resin. The results are shown in Table 2. There was a significant difference in the hardness of bulk-fill composite resin irradiated at different distances in all group ($p < 0,05$).



Table 2. Effect of curing distance on the hardness of the bulk-fill composite resin.

(I) Curing distance	Curing distance	Mean Difference	Std.Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
0 mm	5 mm	31.7400*	.5092	.000	30.381	33.099
	9 mm	58.5800*	.5092	.000	57.221	59.939
5 mm	0 mm	31.7400*	.5092	.000	33.099	30.381
	9 mm	26.8400*	.5092	.000	25.481	28.199
9 mm	0 mm	58.5800*	.5092	.000	59.939	57.221
	5 mm	26.8400*	.5092	.000	28.199	25.481

Discussion

This current study was evaluating the hardness of bulk-fill resin based composite. This restorative material is increasingly being used in posterior teeth that are subjected to a high mastication force. Therefore, hardness is one of the important properties that need to be evaluated. A previous study suggested that the ideal hardness value for composite is exceeding 50 VHN. In this current investigation, the hardness value is more than 50 VHN except for the specimens group with curing distance of 9 mm.¹⁰

All groups in this study showed the same trend, where the hardness of the upper surface was higher than the bottom. Irradiation carried out close to the surface of the resin composite will result in adequate polymerization. However, on the bottom surface light of the light-curing unit will be dispersed.¹⁰ Filler particles can hinder light transmission by scattering and refraction at the resin-filler interface. As expected, the irradiance values significantly decreased with increasing the distance between the light curing tip with the surface of resin composite. These findings are consistent with the literature.¹¹

According to previous study, the ratio between top and bottom surface could be used to measure curing efficiency and the value should be 90%. However, other study stated that the hardness ratio can be at least 80%.¹⁰ This is not consistent with our findings, where the hardness ratio of specimens group with curing distances of 5 and 9 mm are below 80%.

The composition of bulk-fill composite resin was different from conventional composite resin. Bulk-fill composite resin has an initiator, that was called ivocerin. Ivocerin was an initiator that



has more sensitive properties when irradiated. Ivocerin could accelerate the polymerization process of bulkfill composite resin. Ivocerin was able to absorb light as deep as 4 mm. Polymer chain formed would be maximized and increased degree of conversion will be achieved if ivocerin was used as an initiator.³ The use of ivocerin which can improve the mechanical properties of composite resin was promising. In addition to its ability to improve mechanical properties, ivocerin was also biocompatible. The results of the XTT assay test stated that ivocerin did not have toxic properties.¹² The addition of ivocerin as an initiator could increase the hardness of bulk-fill composite resins.

Conclusion

Based on the results of this study, there is a statistically significant effect of the irradiation distance on the hardness of bulk-fill composite resins.

REFERENCES

1. Anusavice KJ, Shen Chiayi, Rawls RH. Phillip's Science of Dental Materials. 12nd ed. St. Louis, Missouri: Elsevier Saunders; 2013. p. 48-75 , 277-297.
2. Czasch P, Ilie N. In Vitro Comparison of Mechanical Properties and Degree of Cure of Bulk Fill Composites. Clin Oral Invest. 2013; 17: 227-235.
3. Moszner N, Fischer UK, Ganster B, Liska R, Rheinberger V. Benzoyl germanium derivatives as novel visible light photoinitiators for dental materials. Dent Mater. 2008 ; 24(7) : 1-7.
4. Vicker Hardness Tester (accessed October 10th 2015). Available from : <http://www.hardnesstesters.com/Applications/Vickers-Hardness-Testing.aspx>
5. Sawa Takeshi. Hardness Test Method, Hardness Tester, and Computer-Readable Storage Medium Storing Program 2011.
6. Ivoclar Vivadent. Scientific Documentation Tetric N-Ceram Bulkfill. <http://asia.ivoclarvivadent.com/en-as/composites/tetric-n-ceram-bulk-fill.2014>. [accessed January 3rd 2016].
7. Nagas IC, Egilmez Ferhan, Ergun Gulfem. The effect of irradiation distance on microhardness of resin composites cured with different light curing units. Eur J Dent. 2010 ; 14 : 136-139.
8. Thome Thais, Jr. Washington, Tachibana Arlene, S.R.M, Lacalle Miriam. Influence of the distance of the curing light source and composite shade on hardness of two composites. Journal of Applied Oral Science 2007 ; 15(6) :486-491.
9. Craig RG, Powers JM. Restorative Dental Materials . 11st ed . St. Louis, Missouri : Mosby; 2002. p. 189-190, 232-241, 245-247.
10. Galvão MR, Caldas SG, Bagnato VS, de Souza Rastelli AN, de Andrade MF. Evaluation of degree of conversion and hardness of dental composites photo-activated with different light guide tips. Eur J Dent. 2013 Jan;7(1):86-93.



11. Al-Zain AO, Eckert GJ, Lukic H, Megremis S, Platt JA. Polymerization pattern characterization within a resin-based composite cured using different curing units at two distances. *Clin Oral Investig*. 2019 Nov;23(11):3995-4010.
12. Lukevics, E. Ignatovich L. Biological activity of organogermanium compounds, In: *The chemistry of organic germanium, tin and lead compounds*, Z. Rappoport (Ed.), Vol. 2, John Wiley&Sons; 2002, 1653-1683.