

Effect of exposure time and distance of the light curing unit on the surface hardness of resin cement

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ABSTRACT

Background: Nowadays, ceramic is the main choice for indirect tooth restoration. Cement plays important role in properties of restoration, especially in fragile material like ceramic.

Objective: This study aimed to evaluate the effect of exposure time and distance of light curing unit on the effectiveness of polymerization of resin cement, assessed by microhardness.

Methods: The dual cured resin cement was inserted into a circular slot in a rectangular metal mold. Then a mylar strip was placed on top of the dual cure resin cement, followed by a ceramic disc that was placed over the rectangular metal mold. Finger pressured was then applied to the ceramic disc. After that, the light curing unit tip was positioned over the upper surface of the ceramic and cured with different times and distances. Specimens were divided into 10 groups. Each specimen was evaluated using a microindentation tester, five indentations were accomplished with a 50-g load applied for 30 seconds. The data were analyzed statistically with two-way ANOVA at 95% significant level.

Results: The results revealed that the closer the distance and the longer the curing time, the greater the surface hardness. The group with 0-mm curing distance and 60-s curing time had significantly superior hardness when compared to other groups. There were significant difference between each distance and curing time.

Conclusion: Both decreasing the distance between the light curing unit tip and the resin cement and increasing the curing time resulted in significantly higher cement's surface hardness.

Keywords: Polymerization, Resin cement, Surface microhardness

INTRODUCTION

Currently, there is an increased demand for esthetic restorations, especially all-ceramic restoration. Therefore, the properties of dental ceramic have been much improved in terms of esthetic, biocompatibility, chemical stability and high compressive strength.¹ The objective of indirect restorations is to restore the morphology of destroyed tooth, providing wear resistance for weakened tooth and longer longevity than direct restorations.²

Longevity of the restoration is one of the most important criteria in choosing the material whereas the restoration success is defined as the demonstrated ability of a restoration to perform as expected, The length that restoration survives is often used as a measure of clinical performance.

There are many factors that are involved in longevity of the restoration; such as patient's oral hygiene, oral habits, dentist's skill and material factors.³ Failure of the restoration is mostly caused by improper biomechanics and tooth preparation, improper cementation techniques, and improper luting agents. Thus luting procedure is a

critical step in providing the best longevity of the restorations.⁴

Resin cement is the newest type of cements with the ability to bond to tooth structure and the surface of the restoration. The most important factor affecting the success of resin cements is the bond strength. Bond strength is affected by pretreatment procedures, depth of cure, degree of conversion and incompatibilities between adhesive resin and resin cement.⁵ Factors that may affect polymerization of the resin cements include cement film thickness, shade of the restoration and opacity or translucency of both cement and restoration.⁶

Distance of light curing tip and exposure time are also important factors to achieve the highest degree of polymerization of resin cement. Inadequate curing is usually associated with poor mechanical and physical properties.⁷ Thus, the effect of exposure time and distance of light curing tip has been proposed. Measuring

the degree of conversion can be done using two methods, the direct method and the indirect method. The direct method includes the FTIR method and Raman spectroscopy. The indirect method includes the use of Knoop micro-hardness and the Vickers micro-hardness. In this experiment we used Vickers hardness to indirectly determine effectiveness of polymerization.⁸ The null hypothesis was there would be no significant difference in Vickers hardness of resin cement, cured with different exposure times and distances of light curing unit.

MATERIALS AND METHODS

The IPS e.max Press (Ivoclar-Vivadent, Schaan, Liechtenstein) was customized to form cylindrical blocks with 4 mm in diameter and 2 mm in height. The 2-piece rectangular mold was made with the smaller piece being able to be separated to allow the cement to be removed without being damaged.

Table 1 The Standard - Composition (in weight %) of Variolink N

Composition (in weight %)	Base paste Batch No. W14935	Catalyst high viscosity Batch No. W84174
Barium glass filler, mixed oxide	48.4	52.2
Dimethacrylates	26.3	22.0
Ytterbiumtrifluoride	25.0	25.0
Initiators and stabilizers	0.3	0.8
Pigments	< 0.1	< 0.1

A dual cure resin cement (Variolink[®] N, Ivoclar-Vivadent, Schaan, Liechtenstein) was used. The resin cement was inserted into a circular slot (diameter = 4 mm, height = 2 mm) in a rectangular metal mold (6×8x2 mm, WxLxH) placed inside a larger rectangular metal mold (3x4x3 mm). Mylar strips (20x20 mm) with 60- microns thickness were placed between the ceramic disc and resin cements. A ceramic disc (diameter=15 mm, height = 2 mm) was placed over the metal

rectangular molds and pressure was applied by a finger to the ceramic disc to displace any excessive cement. The tip of the light curing unit was positioned over the upper surface of the ceramic which was held by the light curing unit stand (Fig. 1). The light curing unit (Demi Plus LED Curing System, Kerr, Detroit, Michigan, USA) with the output peak wavelength range of 450-470 nm, power density of 1,100-1,300 mW/cm² with beam diameter of 7 mm was used.

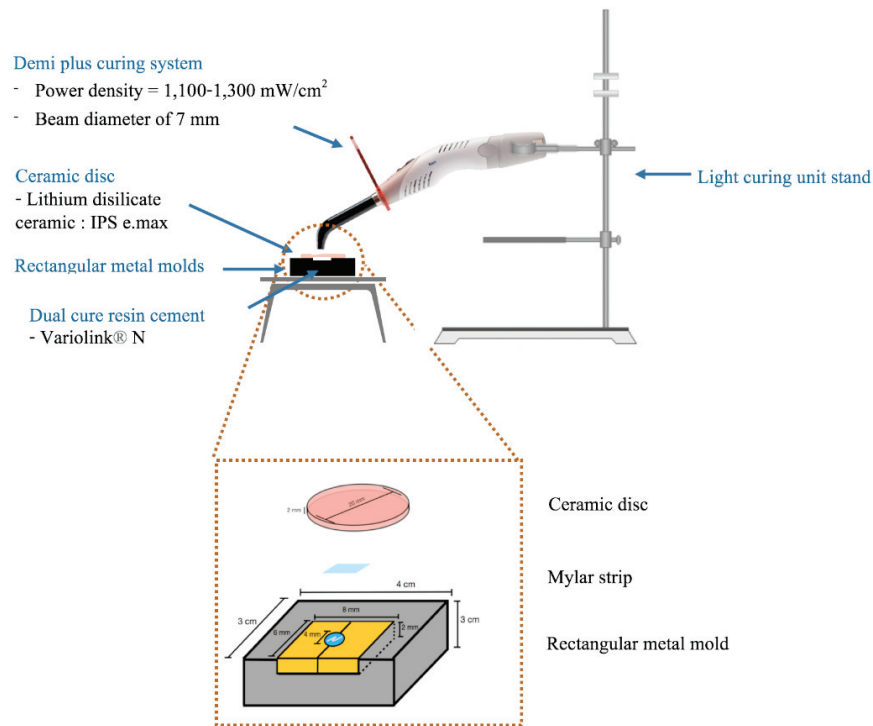


Fig. 1 Experimental set up.

Ten specimens were prepared for each group.

“ Group A (D0, C20): Curing distance 0 mm and curing time 20 seconds.

“ Group B (D5, C20): Curing distance 5 mm and curing time 20 seconds.

“ Group C (D10, C20): Curing distance 10 mm and curing time 20 seconds.

“ Group D (D0, C40): Curing distance 0 mm and curing time 40 seconds.

“ Group E (D5, C40): Curing distance 5 mm and curing time 40 seconds.

“ Group F (D10, C40): Curing distance 10 mm and curing time 40 seconds.

“ Group G (D0, C60): Curing distance 0 mm and curing time 60 seconds.

“ Group H (D5, C60): Curing distance 5 mm and curing time 60 seconds.

“ Group I (D10, C60): Curing distance 10 mm and curing time 60 seconds.

“ Group J (Not cured): The specimen was not exposed to light curing unit.

The specimens were stored in distilled water at 37°C in the dark room and under 100% humidity. The measurement of surface hardness was performed after the specimens being cured for 24 hours. Vicker hardness (VHN) was evaluated using a micro-indentation tester (FM810 Type D, FUTURE TECH, Kawasaki, Kanagawa, Japan) for each specimen. Five indentations were tested with a 50-g load for 30 seconds.

Data analysis

The data were analyzed with IBM SPSS Statistics®. Two way ANOVA was used to compare Vickers hardness values. Tukey’s post hoc test was used to determine the statistical significance among groups based on curing distance and exposure time.

RESULTS

The results illustrated that the closer the distance and the longer the curing time, the greater the surface hardness. It revealed that in group G (D0, C60), the surface hardness was significantly superior when

compared to other groups and the group with the lowest surface hardness was group J (not cured).

The results of Tukey's multiple comparison post hoc test are presented in Table 2.

Table 2 Mean \pm standard deviation of Vickers hardness of resin cement with different curing times and distances.

Distance \ Time	C20	C40	C60	Not cured
D0	36.85 ^g \pm 0.29	39.56 ^h \pm 0.27	41.29 ⁱ \pm 0.18	-
D5	33.42 ^d \pm 0.37	34.20 ^e \pm 0.19	36.30 ^f \pm 0.18	-
D10	31.17 ^b \pm 0.28	32.63 ^c \pm 0.16	33.89 ^e \pm 0.25	-
Not cured	-	-	-	9.57 ^a

D = Curing distance (0, 5, 10 mm), C = Curing time (20, 40, 60 s)

Superscript letters indicate statistical differences ($p < 0.05$).

DISCUSSION

Resin cements are cements used in indirect restorations since they have the ability to bond to the tooth structure. Adequate polymerization of resin cement will result in high bond strength.⁹ Recent studies have shown that inadequate cement polymerization under ceramic restoration is related to insufficient amount of light (energy density) radiation to activate monomer.¹⁰ The effectiveness of light to initiate polymerization of resin-based materials requires the appropriate wavelength determined by the type of photoinitiator incorporated in the resin-based material.¹ Camphorquinone is effectively activated by light at a wavelength range of 375–500 nm, with a peak maximum absorption at 468–470 nm and also by a light intensity high enough to activate polymerization. Factors affecting light efficiency include the light-curing unit, exposure time, and any object between the light tip and the resin cement.

The results of the current study rejected the null hypothesis, hence, confirming the effect of curing time and distance. The present study showed that a smaller distance between the light curing unit tip and the resin cement, and a longer curing time resulted in significantly higher surface hardness of the cement. Corey *et al.*¹¹

showed that the higher the distance from the light curing unit to the specimen, the lower the light intensity and hence, the amount of total energy. These findings supported our results as group G (D0, C60) with the least curing distance had the highest surface hardness due to the highest amount of total energy. Moreover, group J which had not been cured had the lowest surface hardness since it did not receive any total energy. Tatiana *et al.*,¹² measured the surface microhardness of 3 groups of dual-cured dental resin cements and found that the uncured group had the lowest surface hardness after 24 hours, 48 hours and 7 days, compared to 20-s and 180-s cured groups which also supported our findings. The increased efficiency of polymerization of resin cement, reflected by the number of double bonds in the methacrylate groups which is converted in to single bonds during the polymerization process presumably explain the increased hardness of the resin cement.

On the other hand, group E (D5, C40) and group I (D10, C60) were not significant although the light intensity was decreased. The total energy might remain constant due to the compensation by increased curing time, as total energy = light intensity \times curing time. Corey *et al.* (11) showed that when curing distance

increased, light intensity decreased and Ilday *et al.*¹³ also showed that longer light exposure time resulted in greater total energy. Future studies should study light intensity in order to accurately measure total energy.

A correlation test showed that higher Vicker's hardness values were associated with higher degree of conversion values.¹⁴ Therefore, longer curing time and the closer the tip of the LED light-curing unit, the more degree of conversion.

CONCLUSION

On the basis of the findings of this in vitro study, the following conclusions were drawn:

1. The closer the tip of the LED light-curing unit from the surface of the resin cement, the greater the surface hardness of the resin cement.
2. The longer exposure time of the LED light-curing unit, the greater the surface hardness of the resin cement.
3. Chemical cure alone cannot provide sufficient polymerization of resin cement. Light curing is necessary to obtain maximum mechanical properties.

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