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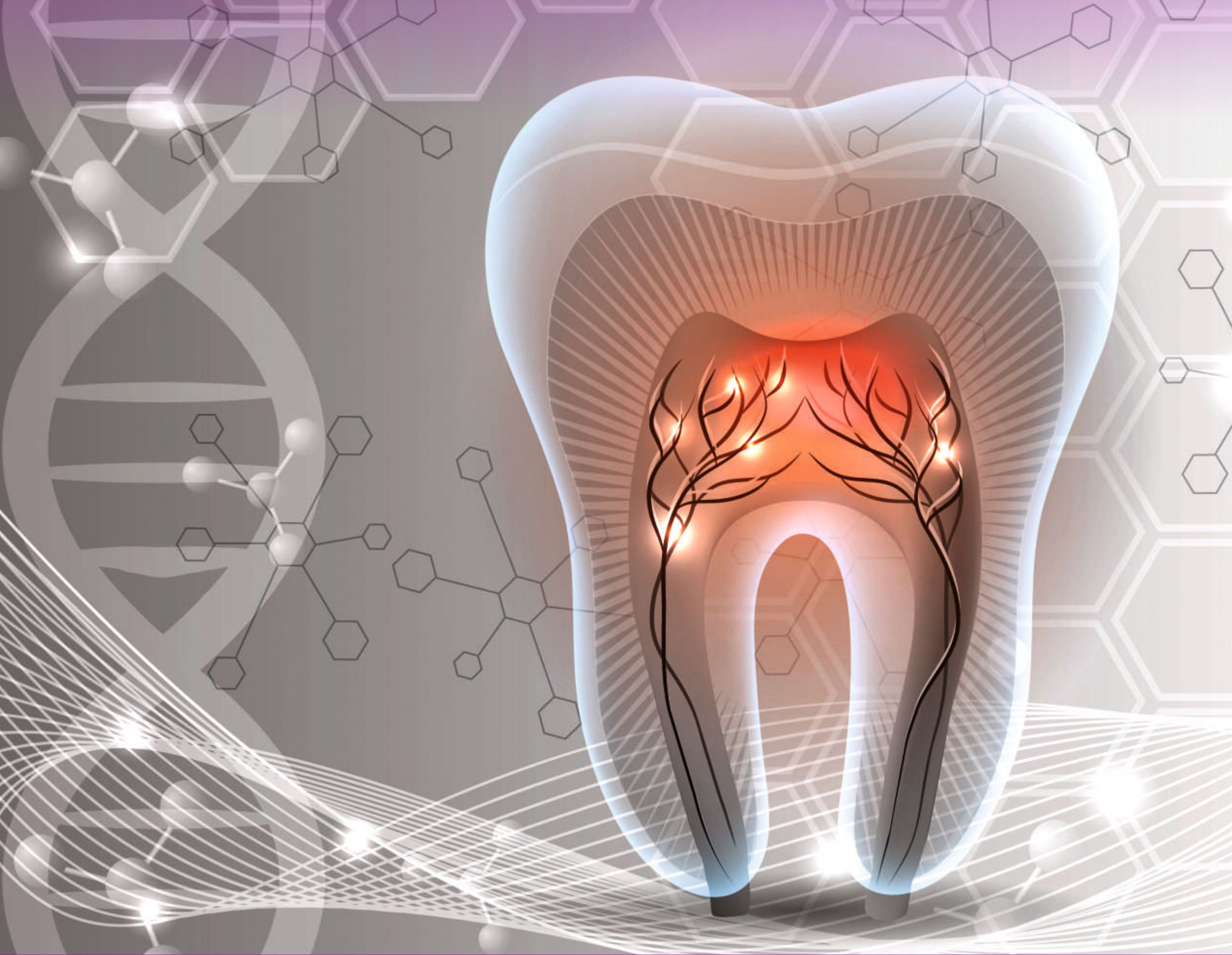

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Original Article

Effect of Light Intensity, Light-Curing Unit Exposure Time, and Porcelain Thickness of IPS e.max press and Vintage LD Press on the Hardness of Resin Cement

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Abstract

Background: Porcelain veneer restoration is the primary choice for indirect restoration, especially for anterior teeth, given its high esthetic properties and lower failure rate than resin composites. Glass-based ceramics such as IPS e.max Press and Vintage LD Press are a choice for veneer due to its superior physical properties. Resin cement is used to attach the veneer restoration to the teeth. The polymerization of resin cement used in veneer restoration affects the stability, mechanical properties, and resistance of the restoration. The composition and thickness of the porcelain material affect the light-curing unit to cured resin cement. **Objectives:** The aim of this study was to evaluate the influence of porcelain thickness, light intensity, and exposure time in the hardness of resin cement. **Methods:** Porcelain samples measuring 5 mm in diameter with three types of thicknesses of IPS e.max Press and Vintage LD Press were used in the study. Resin cement in a metal mold was placed under a porcelain sample before curing with a light-emitting diode (LED) intensity of 1300 or 1700 mW/cm^2. The hardness test was then carried out on the bottom of the resin cement. **Result:** The highest hardness value was obtained from a Vintage LD Press with a thickness of 0.7 mm (cured at 1300 mW/cm^2 for 20 s). A four-way ANOVA test showed significant differences for brands, thicknesses, and times of exposure ($P < 0.05$) as well as insignificant difference for LED intensity. **Conclusion:** The study indicates that polymerization of resin cement with lower thickness presented higher hardness values. Irradiation time affected hardness, while LED intensity did not.

Keywords: *Hardness, intensity, light-emitting diode, porcelain, resin cement, veneer*

Background

Dental porcelain is a popular material that has been widely accepted for the indirect restoration of anterior teeth, offering the best results in esthetic dentistry by applying the principle of minimal preparation only on enamel for the treatment of esthetic and functional problems in the anterior region.[1-4] Porcelain veneer restoration has several advantages over composite, such as higher strength, better color stability, ability to withstand abrasion, better surface smoothness, and less plaque retention.[3] The use of porcelain veneers in the field of esthetic dentistry is the main choice because this material has good esthetic properties with the ability to survive in the mouth for a long time.[4,5]

Several factors that influence the success of porcelain veneer restoration are the treatment plan, type of preparation, enamel support, tooth vitality, choice of ceramic types, and types of adhesive resin cement.[6] The types of ceramics commonly used for porcelain veneers are glass-based ceramics (namely, feldspathic porcelain) and glass-based ceramics with fillers (such

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as leucite and lithium disilicate). Glass-based ceramics have good optical properties such as high translucency, and the color harmony between veneer and adjacent teeth is essential, making it suitable for veneers.[4,7] Glass-based porcelain material is often synthetic with its glass phase combined with apatite crystals and leucite for thermal compatibility with metal expansion and increased strength.[8] IPS e.max Press (Ivoclar, Vivadent) produces pressable ingots of synthetic glass-based porcelain with lithium disilicate glass ceramic. IPS e.max Press's microstructure consists of roughly 70% lithium disilicate ($Li_2Si_2O_5$) crystals (3–6 μm in length) embedded in a glass matrix.[9] Vintage LD Press (Shofu Inc.) also produces a lithium disilicate press glass-based ceramic ingot with four available levels of transparency: high translucent (T), moderately translucent, low opacity, and medium opacity.[10] Their microstructure consists of an interlocking system of acicular crystals embedded in a glass matrix. [11] The microstructure of ceramics, especially in crystalline phase, may influence the polymerization process of underlying resin cement due to their differences in transmittance and scattering of light.[11]

The adhesive used to attach porcelain veneers is resin cement, which needs to be polymerized with the help of a light-curing device.[5,12,13] Resin cement consists of methacrylate or bisphenol A-glycidyl methacrylate. Light-cured resin cement generally contains a camphorquinone photoinitiator.[14] Camphorquinone is effective when activated by light possessing a wavelength of 375–500 nm, with a maximum peak absorption at 468–470 nm.[15] The polymerization of resin cement is influenced by the intensity, wavelength, and irradiation time of the device. The Vickers hardness test commonly used as a simple and reliable method of indicating the degree of resin cement conversion; there is a direct relationship between the degree of conversion (DC) and the hardness during polymerization, increasing material stiffness and strength.[16,17] The clinical performance of ceramic restorations depends on the adequate cementation of the tooth structure of the resin cement; the polymerization of resin cement under ceramic restoration is the most important factor for obtaining optimal physical properties.[18]

The high intensity of the light-curing device creates a high cross-linked polymer chain that increases the cement's hardness rate, but increasing the irradiation time from 20 to 40 s does not increase the degree of resin cement conversion.[19] The use of light-emitting diodes (LEDs) with high intensity (1000–1600 mW/cm^2) can reduce the irradiation time of resin cement.[19]

The thickness and composition of porcelain veneers affect the light used to cure resin cement, preventing maximum hardness, if the veneer is thicker than 0.7 mm.[20] The intensity of light emissions is reduced by 40%–50% when passing through ceramic veneers, making ceramic thickness an important factor in reducing light intensity compared to its color and opacity of ceramic. The microstructure of ceramic materials, especially in the crystalline phase, can influence the polymerization process of the cement below because of the difference in the transmission and spread of light.[11] The recommended minimum intensity for adequate polymerization of resin cement is 400 mW/cm^2.[21] High-intensity light-curing units make the cross-linked polymer chain higher so that the hardness rate is higher. The DC of resin cement is influenced by the polymerization reaction, which depends on the energy released during irradiation as a result of light intensity and irradiation time.[22]

The purpose of this study was to evaluate the influence of porcelain thickness, light intensity, and exposure time in the hardness of resin cement for IPS e.max Press and Vintage LD Press.

Materials and Methods

A sample set of 72 porcelain pieces were obtained. Each piece had a diameter of 5 mm. In the set, 36 Vintage LD Press ingot shade T1 PN 8350 samples (Shofu Inc., Kyoto, Japan) and 36 IPS e.max Press A1 samples (Ivoclar Vivadent, Schaan, Liechtenstein) were divided into three groups of 12 pieces from each manufacturer. The samples differed in thickness (0.7, 1, and 1.5 mm). Each group of thickness was divided into two groups for cured with different LED intensity and further into two subgroups with three samples each to be cured at different time.

RelyX Veneer 3M ESPE light-cured resin cement (St. Paul, MN, USA, Batch No. N946754 with translucent shade) was placed in a 1-mm thick metal mold. A porcelain sample was then placed on top of the resin cement before being given a 200 g load for 20 s.[22-24] The resin cement was subsequently cured using an LED-curing light (Xlite3, ThreeH, China, and Saab KY-L033, 7W, Foshan Keyuan Medical Equipment Co., Ltd, Foshan, China). Three samples were cured for 10 s and three for 20 s [Figure 1].

After curing, the samples were stored for 24 h in dry and dark containers at room temperature.[22,24] The bottom of each sample's cement was then tested randomly in three locations with a microhardness tester unit (Micro Vickers Hardness Tester type HMV-G21ST, Shimadzu Corporation, Kyoto, Japan).

We calculated the mean and standard deviation of hardness for each group. Each group was analyzed using

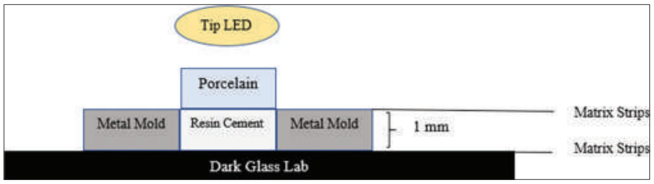

Figure 1: Schematic of light polymerization resin cement under porcelain

Stata software version 14 (StataCorp LP 14.0 1985-2015, StataCorp LLC, College Station, Texas, USA) and a Shapiro–Wilk data normality test. If the data were distributed normally, statistical testing was continued with a four-way ANOVA and Tukey's test.

Results

The intensity measurements from the two LED devices produced an average of 1303.33 mW/cm^2 for the Xlite3 and 1713 mW/cm^2 for the Saab KY-L033. The highest hardness was obtained from the Vintage LD Press samples with a thickness of 0.7 mm cured at 1300 mW/cm^2 for 20 s (56.41), while the lowest hardness was obtained using IPS e.max Press samples with a thickness of 1.5 mm cured at the same intensity and duration [43.56, Table 1].

Four-way ANOVA [Table 2] of the hardness resin cement showed a significant effect for factors thickness, exposure time of light-curing unit between IPS e.max Press and Vintage LD Press ($P < 0.05$).

The *post hoc* Tukey's test [Table 3] showed that the IPS e.max Press and Vintage LD Press differed significantly ($P < 0.05$), with the latter producing better hardness. For porcelain thickness values, the results obtained were significantly different ($P < 0.05$) between thicknesses 1 and 1.5 mm versus 0.7 mm. There was statistically significant difference in hardness when the resin cement cured for 20 s versus 10 s ($P = 0.004$).

Table 1: Mean microhardness (Vickers hardness number) values for IPS e.max Press and Vintage LD press samples with different thicknesses

Thickness (mm)	LED (mW/cm^2)	Time (s)	IPS e.max	Vintage LD
0.7	1300	10	50.69±3.40	52.39±2.68
		20	53.28±4.70	56.41±3.72
	1700	10	49.79±2.49	52.52±1.34
		20	51.96±3.72	48.78±2.39
1	1300	10	45.09±1.84	48.29±1.81
		20	46.98±5.27	51.26±1.92
	1700	10	43.63±1.52	48.62±2.52
		20	49.78±1.55	51.19±2.60
1.5	1300	10	45.96±4.17	46.15±3.14
		20	43.56±5.35	48.08±3.78
	1700	10	45.44±1.82	52.65±1.38
		20	51.63±3.47	53.23±0.70

LED: Light-emitting diode

Table 2: Comparison of hardness to the type porcelain, thickness, intensity light-emitting diode, and time using four-way ANOVA

Variables	df	*F*	*P*>*F*
Type	1	26.76	0.0000
Thickness	2	24.04	0.0000
Intensity	1	3.26	0.0734
Time	1	16.46	0.0001
Time#thickness#intensity#time	18	4.01	0.0000

LED: Light-emitting diode

Table 3: Statistical result *post hoc* Tukey's test

Hardness	*t*	*P*>*t*
Type	−3.82	0.0000
Thickness 1 mm versus 0.7 mm	−4.75	0,0000
Thickness 1.5 mm versus 0.7 mm	−4.47	0.0000
Thickness 1.5 mm versus 1 mm	0.28	0.956
Intensity	1.28	0.203
Time (20 s vs. 10 s)	2.94	0.004

Discussion

The properties of dental resin material depend on various factors (such as monomer characteristics, polymers, fillers, photo-curing process, concentration of the material, curing light unit, intensity of the light, and duration of exposure), which can affect the suitability of the clinical application of these materials. The physical properties of dental material are indicators that the material will survive in the oral environment.[25] Polymerization of resin cement is crucial to achieve optimal cement properties.[20]

The hardness values in this study were highest with Vintage LD Press porcelain at a thickness of 0.7 mm cured at 1300 mW/cm^2 for 20 s [Table 2]. The hardness test was performed after 24 h because the mean value of hardness was higher at that point when compared to measurements taken after 15 min.[23] All sample specimens were stored in dark and dry conditions before testing to prevent influence from ambient light on polymerization.[25] A decrease in the value of hardness was seen with increasing thickness, which was consistent with other studies that stated additional thickness reduced hardness or DC.[18,26,27]

The hardness number in this study was higher at 20 s than at 10 s, indicating statistically significant differences [Table 2]. This result is consistent with other studies that state 20 s of irradiation is recommended to achieve better mechanical properties, while a longer exposure time of up to 40 s provided no better effect.[28] There is a significant difference if the irradiation time is increased from 10 to 30 s, but increasing the irradiation time to 40, 50, and 60 s yielded no longer influence on the Vickers hardness number.[26] Other studies that compared irradiation times of 20–180 s presented results that did not differ significantly in hardness value.[25] Irradiation curing time is necessary and useful for increasing the efficiency of resin cement polymerization.[29]

The use of high-intensity LED should be able to shorten exposure times, but the results of this study are different because the intensity of the two devices and their exposure times are not significantly different [Table 2]. The high-intensity light of the curing unit was necessary for resin cement polymerization because this unit was able to make adequately polymerized resin cement in a short time compared to the lower intensity light.[30] The high-intensity light-curing unit made the cross-linked polymer chain greater, increasing the hardness number. The resin cement DC was influenced by the polymerization reaction, which depended on the energy released during irradiation as a result of light intensity and irradiation time.[22] The intensity of light-curing unit according to the ISO standards is 300 mW/cm^2 with wavelengths of 400–515 nm.[31]

Conclusion

Composition, porcelain thickness, and irradiation time affect resin cement hardness, but not LED intensity. The thinner of porcelain thickness and increasing polymerization time had a positive effect on hardness light-cured resin cement. The difference of crystalline phase of glass-based ceramics affects light transmission to cured resin cement under porcelain.

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Conflicts of interest

There are no conflicts of interest.

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Rosalina Tjandrawinata

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Effect of Light Intensity, Light-Curing Unit Exposure Time, and Porcelain Thickness of IPS e.max press and Vintage LD Press on the Hardness of Resin Cement

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ABSTRACT

Background: Porcelain veneer restoration is the primary choice for indirect restoration, especially for anterior teeth, given its high esthetic properties and lower failure rate than resin composites. Glass-based ceramics such as IPS e.max Press and Vintage LD Press are a choice for veneer due to its superior physical properties. Resin cement is used to attach the veneer restoration to the teeth. The polymerization of resin cement used in veneer restoration affects the stability, mechanical properties, and resistance of the restoration. The composition and thickness of the porcelain material affect the light-curing unit to cured resin cement. **Objectives:** The aim of this study was to evaluate the influence of porcelain thickness, light intensity, and exposure time in the hardness of resin cement. **Methods:** Porcelain samples measuring 5 mm in diameter with three types of thicknesses of IPS e.max Press and Vintage LD Press were used in the study. Resin cement in a metal mold was placed under a porcelain sample before curing with a light-emitting diode (LED) intensity of 1300 or 1700 mW/cm^2. The hardness test was then carried out on the bottom of the resin cement. **Result:** The highest hardness value was obtained from a Vintage LD Press with a thickness of 0.7 mm (cured at 1300 mW/cm^2 for 20 s). A four-way ANOVA test showed significant differences for brands, thicknesses, and times of exposure ($P < 0.05$) as well as insignificant difference for LED intensity. **Conclusion:** The study indicates that polymerization of resin cement with lower thickness presented higher hardness values. Irradiation time affected hardness, while LED intensity did not.

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KEYWORDS: *Hardness, intensity, light-emitting diode, porcelain, resin cement, veneer*

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BACKGROUND

Dental porcelain is a popular material that has been widely accepted for the indirect restoration of anterior teeth, offering the best results in esthetic dentistry by applying the principle of minimal preparation only on enamel for the treatment of esthetic and functional problems in the anterior region.[1-4] Porcelain veneer restoration has several advantages over composite, such as higher strength, better color stability, ability to withstand abrasion, better surface smoothness, and less plaque retention.[3] The use of porcelain veneers in the field of esthetic dentistry is the main choice because this material has good esthetic properties with the ability to survive in the mouth for a long time.[4,5]

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Several factors that influence the success of porcelain veneer restoration are the treatment plan, type of preparation, enamel support, tooth vitality, choice of ceramic types, and types of adhesive resin cement.[6] The types of ceramics commonly used for porcelain veneers are glass-based ceramics (namely, feldspathic porcelain) and glass-based ceramics with fillers (such

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as leucite and lithium disilicate). Glass-based ceramics have good optical properties such as high translucency, and the color harmony between veneer and adjacent teeth is essential, making it suitable for veneers.[4,7] Glass-based porcelain material is often synthetic with its glass phase combined with apatite crystals and leucite for thermal compatibility with metal expansion and increased strength.[8] IPS e.max Press (Ivoclar, Vivadent) produces pressable ingots of synthetic glass-based porcelain with lithium disilicate glass ceramic. IPS e.max Press's microstructure consists of roughly 70% lithium disilicate ($Li_2Si_2O_5$) crystals (3–6 μm in length) embedded in a glass matrix.[9] Vintage LD Press (Shofu Inc.) also produces a lithium disilicate press glass-based ceramic ingot with four available levels of transparency: high translucent (T), moderately translucent, low opacity, and medium opacity.[10] Their microstructure consists of an interlocking system of acicular crystals embedded in a glass matrix. [11] The microstructure of ceramics, especially in crystalline phase, may influence the polymerization process of underlying resin cement due to their differences in transmittance and scattering of light.[11]

The adhesive used to attach porcelain veneers is resin cement, which needs to be polymerized with the help of a light-curing device.[5,12,13] Resin cement consists of methacrylate or bisphenol A-glycidyl methacrylate. Light-cured resin cement generally contains a camphorquinone photoinitiator.[14] Camphorquinone is effective when activated by light possessing a wavelength of 375–500 nm, with a maximum peak absorption at 468–470 nm.[15] The polymerization of resin cement is influenced by the intensity, wavelength, and irradiation time of the device. The Vickers hardness test commonly used as a simple and reliable method of indicating the degree of resin cement conversion; there is a direct relationship between the degree of conversion (DC) and the hardness during polymerization, increasing material stiffness and strength.[16,17] The clinical performance of ceramic restorations depends on the adequate cementation of the tooth structure of the resin cement; the polymerization of resin cement under ceramic restoration is the most important factor for obtaining optimal physical properties.[18]

The high intensity of the light-curing device creates a high cross-linked polymer chain that increases the cement's hardness rate, but increasing the irradiation time from 20 to 40 s does not increase the degree of resin cement conversion.[19] The use of light-emitting diodes (LEDs) with high intensity (1000–1600 mW/cm^2) can reduce the irradiation time of resin cement.[19]

The thickness and composition of porcelain veneers affect the light used to cure resin cement, preventing maximum hardness, if the veneer is thicker than 0.7 mm.[20] The intensity of light emissions is reduced by 40%–50% when passing through ceramic veneers, making ceramic thickness an important factor in reducing light intensity compared to its color and opacity of ceramic. The microstructure of ceramic materials, especially in the crystalline phase, can influence the polymerization process of the cement below because of the difference in the transmission and spread of light.[11] The recommended minimum intensity for adequate polymerization of resin cement is 400 mW/cm^2.[21] High-intensity light-curing units make the cross-linked polymer chain higher so that the hardness rate is higher. The DC of resin cement is influenced by the polymerization reaction, which depends on the energy released during irradiation as a result of light intensity and irradiation time.[22]

The purpose of this study was to evaluate the influence of porcelain thickness, light intensity, and exposure time in the hardness of resin cement for IPS e.max Press and Vintage LD Press.

Materials and Methods

A sample set of 72 porcelain pieces were obtained. Each piece had a diameter of 5 mm. In the set, 36 Vintage LD Press ingot shade T1 PN 8350 samples (Shofu Inc., Kyoto, Japan) and 36 IPS e.max Press A1 samples (Ivoclar Vivadent, Schaan, Liechtenstein) were divided into three groups of 12 pieces from each manufacturer. The samples differed in thickness (0.7, 1, and 1.5 mm). Each group of thickness was divided into two groups for cured with different LED intensity and further into two subgroups with three samples each to be cured at different time.

RelyX Veneer 3M ESPE light-cured resin cement (St. Paul, MN, USA, Batch No. N946754 with translucent shade) was placed in a 1-mm thick metal mold. A porcelain sample was then placed on top of the resin cement before being given a 200 g load for 20 s.[22-24] The resin cement was subsequently cured using an LED-curing light (Xlite3, ThreeH, China, and Saab KY-L033, 7W, Foshan Keyuan Medical Equipment Co., Ltd, Foshan, China). Three samples were cured for 10 s and three for 20 s [Figure 1].

After curing, the samples were stored for 24 h in dry and dark containers at room temperature.[22,24] The bottom of each sample's cement was then tested randomly in three locations with a microhardness tester unit (Micro Vickers Hardness Tester type HMV-G21ST, Shimadzu Corporation, Kyoto, Japan).

We calculated the mean and standard deviation of hardness for each group. Each group was analyzed using

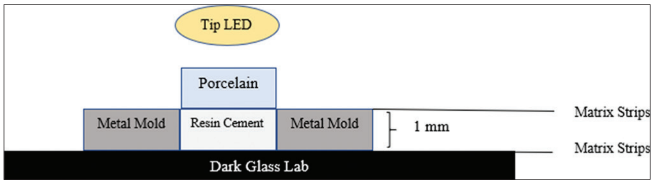

Figure 1: Schematic of light polymerization resin cement under porcelain

Stata software version 14 (StataCorp LP 14.0 1985-2015, StataCorp LLC, College Station, Texas, USA) and a Shapiro–Wilk data normality test. If the data were distributed normally, statistical testing was continued with a four-way ANOVA and Tukey's test.

Results

The intensity measurements from the two LED devices produced an average of 1303.33 mW/cm^2 for the Xlite3 and 1713 mW/cm^2 for the Saab KY-L033. The highest hardness was obtained from the Vintage LD Press samples with a thickness of 0.7 mm cured at 1300 mW/cm^2 for 20 s (56.41), while the lowest hardness was obtained using IPS e.max Press samples with a thickness of 1.5 mm cured at the same intensity and duration [43.56, Table 1].

Four-way ANOVA [Table 2] of the hardness resin cement showed a significant effect for factors thickness, exposure time of light-curing unit between IPS e.max Press and Vintage LD Press ($P < 0.05$).

The *post hoc* Tukey's test [Table 3] showed that the IPS e.max Press and Vintage LD Press differed significantly ($P < 0.05$), with the latter producing better hardness. For porcelain thickness values, the results obtained were significantly different ($P < 0.05$) between thicknesses 1 and 1.5 mm versus 0.7 mm. There was statistically significant difference in hardness when the resin cement cured for 20 s versus 10 s ($P = 0.004$).

Table 1: Mean microhardness (Vickers hardness number) values for IPS e.max Press and Vintage LD press samples with different thicknesses

Thickness (mm)	LED (mW/cm^2)	Time (s)	IPS e.max	Vintage LD
0.7	1300	10	50.69±3.40	52.39±2.68
		20	53.28±4.70	56.41±3.72
	1700	10	49.79±2.49	52.52±1.34
		20	51.96±3.72	48.78±2.39
1	1300	10	45.09±1.84	48.29±1.81
		20	46.98±5.27	51.26±1.92
	1700	10	43.63±1.52	48.62±2.52
		20	49.78±1.55	51.19±2.60
1.5	1300	10	45.96±4.17	46.15±3.14
		20	43.56±5.35	48.08±3.78
	1700	10	45.44±1.82	52.65±1.38
		20	51.63±3.47	53.23±0.70

LED: Light-emitting diode

Table 2: Comparison of hardness to the type porcelain, thickness, intensity light-emitting diode, and time using four-way ANOVA

Variables	df	*F*	*P>F*
Type	1	26.76	0.0000
Thickness	2	24.04	0.0000
Intensity	1	3.26	0.0734
Time	1	16.46	0.0001
Time#thickness#intensity#time	18	4.01	0.0000

LED: Light-emitting diode

Table 3: Statistical result *post hoc* Tukey's test

Hardness	*t*	*P>t*
Type	−3.82	0.0000
Thickness 1 mm versus 0.7 mm	−4.75	0,0000
Thickness 1.5 mm versus 0.7 mm	−4.47	0.0000
Thickness 1.5 mm versus 1 mm	0.28	0.956
Intensity	1.28	0.203
Time (20 s vs. 10 s)	2.94	0.004

Discussion

The properties of dental resin material depend on various factors (such as monomer characteristics, polymers, fillers, photo-curing process, concentration of the material, curing light unit, intensity of the light, and duration of exposure), which can affect the suitability of the clinical application of these materials. The physical properties of dental material are indicators that the material will survive in the oral environment.[25] Polymerization of resin cement is crucial to achieve optimal cement properties.[20]

The hardness values in this study were highest with Vintage LD Press porcelain at a thickness of 0.7 mm cured at 1300 mW/cm^2 for 20 s [Table 2]. The hardness test was performed after 24 h because the mean value of hardness was higher at that point when compared to measurements taken after 15 min.[23] All sample specimens were stored in dark and dry conditions before testing to prevent influence from ambient light on polymerization.[25] A decrease in the value of hardness was seen with increasing thickness, which was consistent with other studies that stated additional thickness reduced hardness or DC.[18,26,27]

The hardness number in this study was higher at 20 s than at 10 s, indicating statistically significant differences [Table 2]. This result is consistent with other studies that state 20 s of irradiation is recommended to achieve better mechanical properties, while a longer exposure time of up to 40 s provided no better effect.[28] There is a significant difference if the irradiation time is increased from 10 to 30 s, but increasing the irradiation time to 40, 50, and 60 s yielded no longer influence on the Vickers hardness number.[26] Other studies that compared irradiation times of 20–180 s presented results that did not differ significantly in hardness value.[25] Irradiation curing time is necessary and useful for increasing the efficiency of resin cement polymerization.[29]

The use of high-intensity LED should be able to shorten exposure times, but the results of this study are different because the intensity of the two devices and their exposure times are not significantly different [Table 2]. The high-intensity light of the curing unit was necessary for resin cement polymerization because this unit was able to make adequately polymerized resin cement in a short time compared to the lower intensity light.[30] The high-intensity light-curing unit made the cross-linked polymer chain greater, increasing the hardness number. The resin cement DC was influenced by the polymerization reaction, which depended on the energy released during irradiation as a result of light intensity and irradiation time.[22] The intensity of light-curing unit according to the ISO standards is 300 mW/cm^2 with wavelengths of 400–515 nm.[31]

Conclusion

Composition, porcelain thickness, and irradiation time affect resin cement hardness, but not LED intensity. The thinner of porcelain thickness and increasing polymerization time had a positive effect on hardness light-cured resin cement. The difference of crystalline phase of glass-based ceramics affects light transmission to cured resin cement under porcelain.

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Conflicts of interest

There are no conflicts of interest.

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