



Effect of Thickness of Resin Matrix Ceramics on Polymerization of Resin Cements

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Cite this article as: Göktepe B, Çelik E, Gönüldaş F. Effect of thickness of resin matrix ceramics on polymerization of resin cements. *Essent Dent.* 2025, 4, 0052, doi: 10.5152/EssentDent.2025.25052.

Abstract

Background: This study aimed to assess how the thickness of resin matrix ceramics (RMC) impacted the microhardness of the underlying resin cement.

Methods: Three types of RMC were analyzed: polymer infiltrated ceramic, resin nano ceramic, and nano ceramic. Every ceramic block had sections 0.5, 1, and 1.5 mm thick and 8 mm in diameter. Nine groups, each containing 10 RMC discs ($n=10$), were produced by combining all the parameters. Central-holed stainless steel that was 6 mm in diameter and 0.5 mm deep was used for applying translucent light-cured luting resin. The resin cement underwent polymerization in direct contact with the RMC. Under a 50 g load and a 15-second indentation duration, Vickers measurements were taken from the underside of the resin cement specimens using 3 distinct indentation locations. The average of the 3 measurements for each specimen was utilized to determine the Vickers hardness value. The data were analyzed using two-way ANOVA and Tukey post hoc tests.

Results: In the case of resin cements with underlying thicknesses of 0.5 mm and 1 mm, the groups GC Cerasmart and Vita Enamic demonstrated significantly higher average microhardness in comparison to the Lava Ultimate group ($P < .05$). Compared to the GC Cerasmart and Vita Enamic groups, the Lava Ultimate group's mean microhardness of the resin cements for a thickness of 1.5 mm was significantly lower ($P < .05$).

Conclusion: Resin matrix ceramics thickness and type had a significant effect on microhardness values in all kinds of RMC.

Keywords: Microhardness, polymerization, resin matrix ceramic, resin cement

What is already known on this topic?

- Insufficiencies in the polymerization of resins lead to various problems in dental applications.
- The thickness and type of the restorative materials influence the microhardness of the resin cement.

What this study adds on this topic?

- Although different studies have investigated the effect of the thickness and type of several restorative materials on the polymerization of the underlying resin cement, this study focused on newly generated resin matrix ceramics.
- Considering the result of this study, the polymer infiltrated ceramic network exhibited the highest Vickers microhardness values across all thicknesses.

INTRODUCTION

Composite and ceramic restorative materials have been utilized in aesthetic restorations for a considerable duration, each material possessing a distinct set of pros and cons.¹ With the advent of novel polymerization methods, new microstructures produced by Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) technology have improved.² Resin matrix ceramics (RMC) are the result of bringing together the durability and color stability advantages of ceramics and the high flexural strength and low abrasion properties of resin composites. These materials are called several names, such as resin nanoceramics (RNC), hybrid ceramics, resin matrix ceramics, ceramic-based

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Received: April 25, 2025
Revision Requested: May 26, 2025
Last Revision Received: June 1, 2025
Accepted: June 30, 2025
Publication Date: October 17, 2025

interpenetrating phase composites, double network materials, and polymer infiltrated ceramic network (PICN).^{3,4}

Lava Ultimate (3M ESPE, Neuss, Germany) is named RNC by the manufacturer. This dental material includes nano ceramic particles in the resin matrix, accounting for 80% of the weight. This high nano ceramic content is composed of zirconia nanoparticles, discrete silica nanoparticles, and zirconia-silica nanoclusters.³ GC Cerasmart (GC, Tokyo, Japan) is called nano ceramic by the manufacturer and consists of 71% by weight filler particles. The filling particles contain silica and barium, while the resin matrix includes bisphenol A ethoxylate dimethacrylate (BisMEPP), urethane dimethacrylate (UDMA), and dimethacrylate (DMA). The usage of GC Cerasmart is recommended for crown, implant-supported crown, veneer, inlay, onlay restorations.⁵ Vita Enamic (Vita Zahnfabrik, Bad Säckingen, Germany) was introduced by the manufacturer as a PICN. As a result of microstructural analysis, PICNs are reported that hybrid materials consisting of interconnected networks.⁶ This material has a double network structure and include a polymer network and a feldspathic ceramic network. Thanks to this double network structure, crack propagation in the material is stopped.³

The classification of composite resin luting cements is based on polymerization types, with 3 categories identified: light-cure, self-cure, and dual-cure.⁷ Color changes occur possibly as a result of the oxidation of reactive groups in amine accelerators and inhibitors in chemically activated systems, like self-cure and dual-cure resin cements. Because these accelerators are present in significantly lower concentrations in light-cure systems, light-curing systems exhibit superior color stability in comparison to dual-cure and self-cure systems.^{8,9}

In the polymerization of composite resins, the conversion of monomers to polymer is defined as the degree of polymerization or degree of conversion. An ideal composite should achieve an optimal degree of conversion with minimal polymerization shrinkage.¹⁰ Various methods are utilized to evaluate resin polymerization, including Fourier Transform Infrared Spectroscopy (FTIR), the scraping method, optical microscopy, and microhardness tests. A diamond-shaped tip applies force to the surface of sample for a specified duration

in microhardness tests. Vickers microhardness test is often preferred for measuring the hardness of dental materials and dental tissue, as it can assess the hardness of various materials, including high-hardness metals and delicate substances.⁷

Several elements influence the degree of polymerization in resin cements, such as resin type, the proportion of filler particles, shape and size of filler particles, thickness and color of resin or restoration, compatibility of restorative material with adhesives, the application time of light source, light source type, the distance between light source tip, light intensity, and resin.¹¹

This study aimed to evaluate the effect of the thickness of RMC materials on the polymerization of resin cements. The null hypothesis of current study is that different RMC blocks and the thickness of the material will not affect the microhardness of the polymerized light-cure resin cement.

MATERIALS AND METHODS

This study examined the impact of 3 different RMC materials at varying thicknesses on the polymerization of light-curing resin cement. Materials used and chemical contents are shown in Table 1.

Since this research does not directly affect humans or animals, ethics committee approval or informed consent statement is not required. The study was carried out by the guiding principles of the Declaration of Helsinki. Resin matrix ceramics blocks with high translucency (HT) and A2 color (12 × 14 × 18 mm) were selected. Blocks in 8 mm diameter were produced by milling RMC blocks in the milling unit (Yenamak D50, Yenadent Ltd, İstanbul, Türkiye). A precision cutting device (Mecatome T180; Presi SA, Angonnes, France) and a diamond wheel saw (Diamond cut-off wheels type LM+ Ø 100 mm, Presi SA, Angonnes, France) were used to cut the RMC blocks into circular slices with thicknesses of 0.5 mm, 1 mm, and 1.5 mm. The cutting was done at 290 rpm while being continuously cooled by water. A silicon carbide sandpaper (Atlas Zımpara, İstanbul, Türkiye) with grits of 600, 800, and 1200 was utilized to polish each specimen. This was subsequently a 10-minute ultrasonic cleaning of the prepared specimens in the ultrasonic bath (Skymen Heatable Ultrasonic Cleaner

Table 1. Materials and Their Chemical Contents Used in the Study

Material	Material Type	Composition	Manufacturer	Shade
Vita Enamic	Polimer infiltrated resin ceramic	Polymer-infiltrated-feldspathic-ceramic-network material (UDMA, TEGDMA) with 86 wt% ceramic (SiO ₂ , Al ₂ O ₃ , Na ₂ O, K ₂ O, and other oxides)	Vita Zahnfabrik, Bad Säckingen, Germany	HT 2M2
GC Cerasmart	Nano ceramic	Composite resin material (Bis-MEPP, UDMA, DMA) with 71 wt% silica and barium glass nanoparticles	GC Dental Products Corp., Aichi, Japan	HT 2M2
Lava Ultimate	Resin nano ceramic	Composite resin material (Bis-GMA, UDMA, Bis-EMA, TEGDMA) with 80 wt% silica and barium glass nanoparticles and zirconia/silica nanoclusters	3M ESPE, Neuss, Germany	HT 2M2
RelyX Veneer	Resin cement	TEGDMA/BisGMA	3 M ESPE, St. Paul, MN, USA	Translucent

HT, high translucency; wt, weight.

JP-4820, Shenzhen, China). For every RMC block (n=10), a total of 90 circular samples (8 mm in diameter) in 3 distinct thicknesses (0.5 mm, 1.0 mm, and 1.5 mm) were made. Each specimen was carefully examined utilizing a digital micrometer (Mitutoyo Corporation, Kanagawa, Japan) to define that its thicknesses of 0.5 mm, 1 mm, and 1.5 mm were consistent.

For the preparation of resin cement samples, stainless steel mold was prepared in order to the thickness and diameter of the resin cement were brought to a certain standard. A space of 6 mm in diameter and 0.5 mm in height was prepared in the interior of the stainless steel mold to place the resin cement. In the upper part of this space, an 8 mm diameter and 0.5 mm high space was prepared to place RMC samples (Figure 1). In the study, the use of a light-cure resin cement RelyX Veneer, (3M ESPE, St. Paul, MN, USA) was preferred. Translucent resin cement is used to prevent the color of the RMC materials from changing. The resin cement is placed in the space prepared in the stainless steel mold without any air bubbles (Figure 2).

Single Bond Universal Adhesive (3M-ESPE, St. Paul, USA) was wiped onto the RMC surfaces that would be in contact with the cement material using the applicator for 20 seconds. Afterward, the excessive bond was removed by applying air for 5 seconds. Bonded RMC samples were placed on the resin cement in the stainless steel mold. Then, a 500 g force was applied over all samples for 20 seconds to standardize the pressure to be applied.¹² After the force was removed, the light-emitting diode (LED) light device (Venus VE-215I, Venus Foshan Medical Company, Guangdong, China) was applied for 30 seconds by contacting the upper surfaces of the RMC samples, and polymerization of the resin cement was performed. The LED used in the polymerization had a power density of 450 mW/cm². Prepared specimens were stored in light-proof and dry containers for 24 hours.

After polymerization, the Vickers microhardness device (HVS-1000 Digital Display Microhardness Tester, China) was utilized to measure the microhardness of the resin cement.

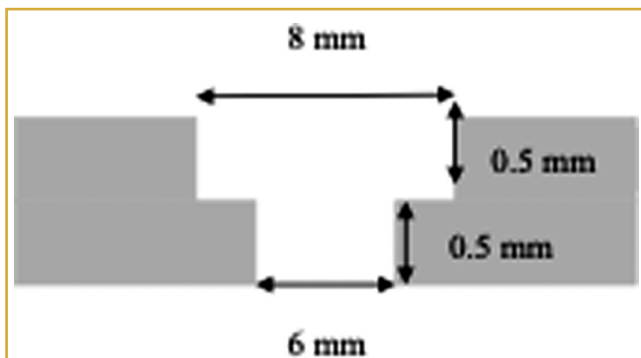


Figure 1. Schematic view of central-holed mold.

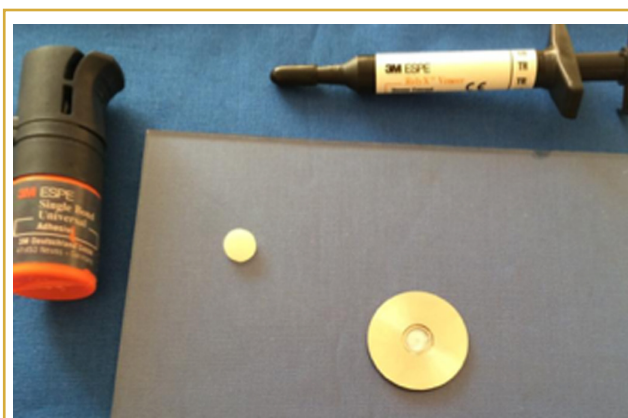


Figure 2. Central-holed stainless steel mold, resin cement, and resin matrix ceramics sample.

The test samples were placed in the microhardness device with the resin cement on top. The Vickers microhardness (VHN) device applied a 50 g load to each sample for 15 seconds. A total of 270 measurements were made, 3 times from each sample. The photographs of the measurements were obtained with the microscope in the microhardness device and then transferred to the computer through the program connected to the microhardness device. As a result of the measurements, Vickers microhardness values of the materials were obtained.

By applying Shapiro-Wilk and Levene's tests, the distribution of the data was evaluated. Data were analyzed statistically using two-way ANOVA and Tukey Honest Significant Difference (HSD) test (IBM SPSS Statistics version 20 software-IBM SPSS Corp.; Armonk, NY, USA).

RESULTS

The VHN values of RelyX Veneer resin cement polymerized using an LED light source under different RMC discs of different thicknesses were compared using two-way ANOVA and Tukey HSD tests. According to the two-way ANOVA test, the material type (A) and the thickness (B) of the RMC samples affect the polymerization of the light-curing resin cement ($P < .05$). The interaction ($A \times B$) of the thickness and material type also seems to be efficient in cement polymerization.

The results of the Tukey multiple comparison test are shown in Table 2. In GC Cerasmart and Vita Enamic groups, the highest hardness values were observed in the resin cement in the 0.5 mm RMC samples, and the lowest hardness values in the resin cement in the 1.5 mm RMC samples. VHN value decreases statistically significantly as the sample thickness increases in GC Cerasmart and Vita Enamic groups ($P < .05$). In the Lava Ultimate group, the 0.5 mm sample group had statistically significantly higher VHN values than the 1 mm and 1.5 mm sample groups ($P < .05$). There was no

Table 2. Comparing Statistical Significance of the Effects of Material Type and Thickness on Polymerization of Resin Cement.

Thickness	0.5 mm		1 mm		1.5 mm	
RMC	Mean/SD	Differences*	Mean/SD	Differences*	Mean/SD	Differences*
GC Cerasmart	25.10 (0.58)	Cb	22.77 (0.94)	Bb	19.02 (1.89)	Aa
Lava Ultimate	19.92 (0.34)	Ba	17.94 (0.78)	Aa	17.86 (0.66)	Aa
Vita Enamic	25.13 (0.65)	Cb	23.56 (0.86)	Bb	20.52 (1.34)	Ab

RMC, resin matrix ceramics. *Different letters, lowercase in column, and uppercase in line indicate significant differences.

statistically significant difference between the groups with thicknesses of 1 mm and 1.5 mm ($P > .05$).

Different RMC groups of the same thickness were also statistically compared. In 0.5 mm thickness groups, GC Cerasmart and Vita Enamic groups were found to have statistically significantly higher VHN values than the Lava Ultimate group ($P < .05$). No statistically significant difference was found between the GC Cerasmart and Vita Enamic groups ($P > .05$).

VHN values of GC Cerasmart and Vita Enamic 1 mm thickness groups were found to be statistically significantly higher than the 1 mm Lava Ultimate group ($P < .05$). The difference between Vita Enamic and GC Cerasmart 1 mm thickness groups is not statistically significant ($P > .05$). In 1.5 mm samples, Vita Enamic showed a statistically significantly higher VHN value in comparison to GC Cerasmart and Lava Ultimate ($P < .05$). Although GC Cerasmart showed higher VHN value than Lava Ultimate, there was no statistically significant difference between them ($P > .05$).

Vita Enamic has shown the highest VHN values in all thicknesses. Lava Ultimate has shown the lowest VHN values in all thicknesses.

In all groups, increasing the thickness of the RMC affects the polymerization of the resin cement and decreases the VHN value. In all material groups, there is a statistically significant difference between 0.5 mm thickness samples and 1.5 mm thickness samples ($P < .05$). When the thickness of the RMC sample increases, polymerization of the resin cement decreases. Figure 3 shows the average VHN values and SD values of all sample groups.

DISCUSSION

The null hypothesis of the study that the material type and thickness will not affect the microhardness of resin cement is rejected based on the data obtained.

Along with recent advancements in CAD/CAM technology, various dental materials with improved biocompatibility, mechanical properties, and aesthetic qualities have been developed. Different companies have introduced RMC systems that combine the advantages of ceramics and composites, and these materials have begun to be utilized in clinics. This study focused on the most preferred RMC materials: GC Cerasmart, Vita Enamic, and Lava Ultimate.

All RMC materials examined in the current study are indicated for use in laminate veneer restorations. In line with this data, the choice of light-cure resin cement in this study was to prevent amine discoloration and maintain color stability in the anterior region over an extended period in laminate veneer restorations. Kilinc et al¹³ investigated the color stability of resin cements and their effects on the color of restorations using both light-cure and dual-cure forms of 3 different resin cements (Nexus-2 / Kerr; Appeal / Ivoclar Vivadent; Calibra / Dentsply). The study's results showed that light-cure resin cements exhibited superior color stability across all 3 cement groups, while in the appeal resin cement, the coloration was significantly higher.¹³ Hekimoğlu et al¹⁴ examined a dual cure, a light cure, and a self cure resin cement in their study and reported that the group with the most significant color change was the self-cure cement group.

Insufficiencies in the polymerization of resins lead to various problems in dental applications. As a result of insufficient polymerization, problems occur, such as increased cytotoxicity of the material, decreased hardness, low modulus of elasticity, fractures in restorations, discoloration, and secondary caries on the edges of the restoration as a result of microleakage.¹⁵ A lot of factors affect the degree of polymerization of resin cements, such as resin type, the proportion of filler particles, shape and size of filler particles, thickness and color of resin or restoration, compatibility of restorative material with adhesives, the application time of light source, light source type, light intensity, and the distance between light source tip and resin.¹¹

One of the factors affecting polymerization is the light intensity of the light device used. Light intensity (mW/cm^2) is described as the light power per unit area. In studies on polymerization, light of sufficient wavelength (400–500 nm) is reported to provide effective polymerization.^{16,17} An LED light source with a light intensity of $450 \text{ mW}/\text{cm}^2$ was chosen for the current study to ensure sufficient polymerization, and the light source applied for 30 seconds in line with similar studies and suggestions of the manufacturer. As the distance between the tip of the light device and the resin material decreases, the quality of the polymerization increases. Prati et al¹⁸ reported that a 1 mm distance increase caused a 10% decrease in light intensity. In this study, to obtain optimal polymerization, the tip of the LED light device was brought into contact with the RMC.

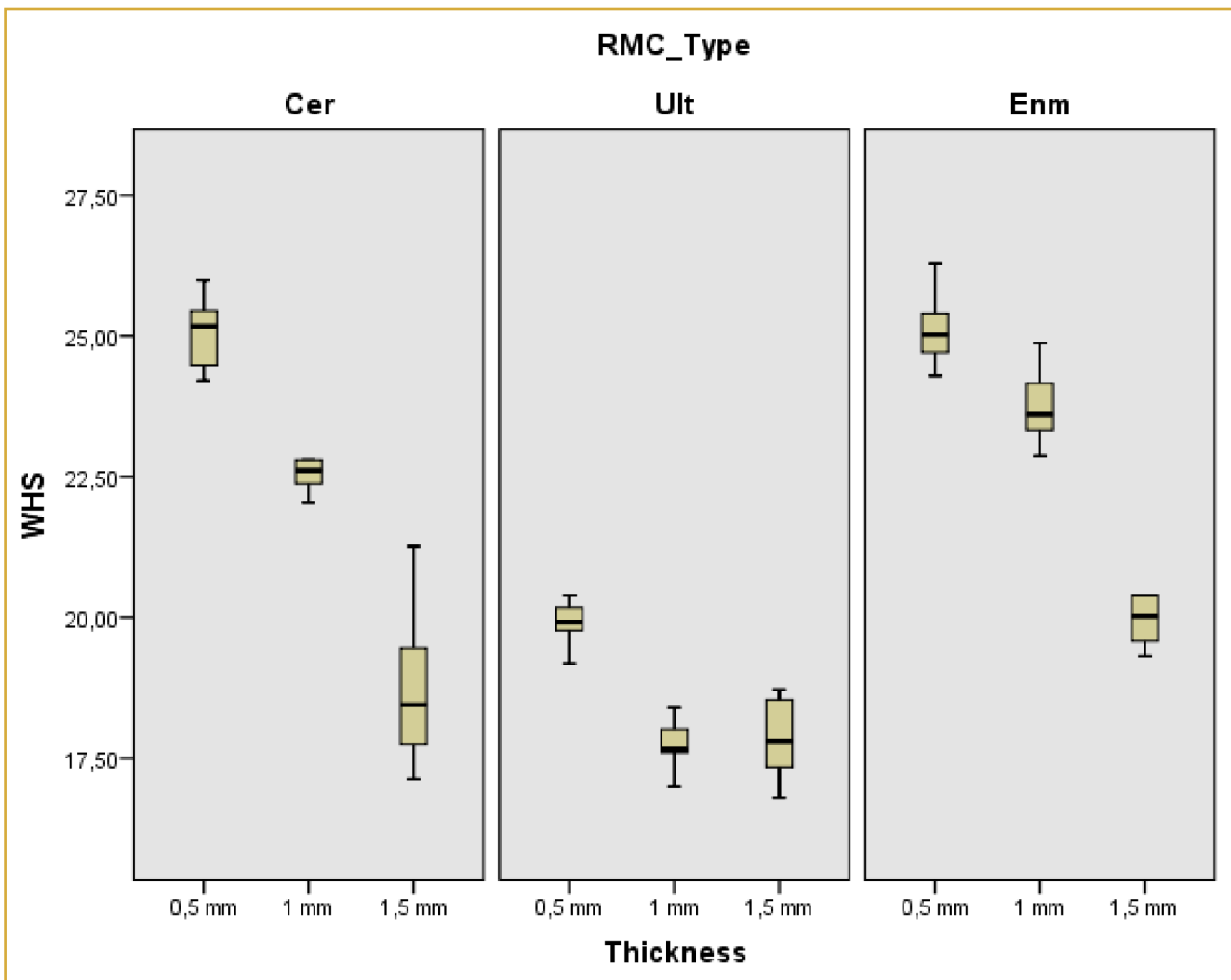


Figure 3. Microhardness values and SDs of samples.

Another factor affecting polymerization is the rate of filler in resin cement. Albino et al¹⁹ reported that the opacity of resin materials and the increase in filler ratio decreased polymerization, as it reduced the light transmittance. In the current study, the usage of light-cured resin cement RelyX Veneer was preferred. RelyX Veneer resin cement is a resin system consisting of TEGDMA/BisGMA. This resin cement contains 0.2–3 µm zirconium/silica filler at a rate of 47% by volume.

The thickness of the restoration significantly impacts the polymerization of the underlying cement. Öztürk et al²⁰ reported that both the thickness and shade of ceramics affect the mechanical properties of light-cured resin cement; specifically, lighter colors and thinner ceramics demonstrate higher light transmittance. Watanabe et al²¹ discovered that increased ceramic thickness results in reduced hardness of the resin cement, particularly for ceramics thicker than 2 mm. Turp et al²² examined the effects of zirconia thickness on the polymerization of resin cements. Their findings

indicated that as zirconia thickness increases, both the microhardness values and polymerization depth of the resin cement decline. Çelik and Göktepe²³ reported that as the thickness of RMC materials increased, translucency parameter values decreased, and opalescence parameter values increased. In this study, RMC materials with thicknesses of 0.5 mm, 1 mm, and 1.5 mm were used to evaluate the impact of ceramic thickness on resin cement polymerization and to compare with previous research. Consistent with earlier studies, an increase in RMC thickness corresponds to a decrease in the microhardness values of the resin cement. It is believed that variations in light transmittance and microhardness values of resin cement are linked to the types and amounts of filler present in the RMC groups.

The thickness of the resin cement is another variable influencing polymerization. Turp et al²⁴ evaluated the polymerization of resin cement at depths of 100 µm, 300 µm, 500 µm, and 700 µm using Vickers microhardness tests, applying

a 50 g force for 15 seconds. The researchers reported that the VHN value of the resin cement decreases as the depth increases. Puppini-Rontani et al.²⁵ measured Knoop hardness by applying a 50 g force for 15 seconds from the top surface, center, and bottom surface of the cement samples.²⁵ In the current study, consistent with similar studies published previously, the thickness of the cement was prepared to be 0.5 mm, and VHN was measured from the lower surface of the cement at a depth of 500 µm. As in previous studies, a 50 g load was applied for 15 seconds in this study.

The VHN values in this current study differ from those in previous studies.^{26–28} There are too many variables related to polymerization, and the research criteria could not be standardized. Since many factors affect the microhardness values of resin cement, the values obtained are not fully compatible with previous studies.

CONCLUSION

The thickness and type of the RMC sample significantly influence the microhardness of the resin cement. The Vita Enamic (PICN) group exhibited the highest VHN values across all thicknesses, while the Lava Ultimate (resin nano ceramic) group displayed the lowest VHN values in every thickness. In all groups, increasing the RMC thickness impacts the polymerization of the resin cement and results in a decrease in the VHN value. In clinical applications, the choice of PICN material for restorations of the same thickness will have a positive effect on the polymerization of the underlying resin cement and therefore on the long-term success of the restoration.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – B.G., E.Ç.; Design – B.G., E.Ç.; Supervision – E.Ç.; Resources – B.G., E.Ç.; Materials – E.Ç., F.G.; Data Collection and/or Processing – B.G., E.Ç., F.G.; Analysis and/or Interpretation – B.G., E.Ç.; Literature Search – B.G.; Writing Manuscript – B.G., E.Ç., F.G.; Critical Review – E.Ç., F.G.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: The research work was conducted with the financial supports of the Scientific Research Projects Unit of Ordu University with project number B-1815.

REFERENCES

- Hampe R, Theelke B, Lümkemann N, Eichberger M, Stawarczyk B. Fracture toughness analysis of ceramic and resin composite CAD/CAM material. *Oper Dent*. 2019;44(4):E190–E201. [\[CrossRef\]](#)
- He LH, Swain M. A novel polymer infiltrated ceramic dental material. *Dent Mater*. 2011;27(6):527–534. [\[CrossRef\]](#)
- Gracis S, Thompson VP, Ferencz JL, Silva NR, Bonfante EA. A new classification system for all-ceramic and ceramic-like restorative materials. *Int J Prosthodont*. 2015;28(3):227–235. [\[CrossRef\]](#)
- Mainjot AK, Dupont NM, Oudkerk JC, Dewael TY, Sadoun MJ. From artisanal to CAD–CAM blocks: state of the art of indirect composites. *J Dent Res*. 2016;95(5):487–495. [\[CrossRef\]](#)
- Stawarczyk B, Liebermann A, Eichberger M, Güth JF. Evaluation of mechanical and optical behavior of current esthetic dental restorative CAD/CAM composites. *J Mech Behav Biomed Mater*. 2015;55:1–11. [\[CrossRef\]](#)
- Della Bona A, Corazza PH, Zhang Y. Characterization of a polymer-infiltrated ceramic-network material. *Dent Mater*. 2014;30(5):564–569. [\[CrossRef\]](#)
- Anusavice KJ, Shen C, Rawls HR. Direct Restorative Materials. *Phillips' Science of Dental Materials*. 12th ed. September 6, 2012.
- Koishi Y, Tanoue N, Atsuta M, Matsumura H. Influence of visible-light exposure on colour stability of current dual-curable luting composites. *J Oral Rehabil*. 2002;29(4):387–393. [\[CrossRef\]](#)
- Buchalla W, Attin T, Hilgers RD, Hellwig E. The effect of water storage and light exposure on the color and translucency of a hybrid and a microfilled composite. *J Prosthet Dent*. 2002;87(3):264–270. [\[CrossRef\]](#)
- Dewaele M, Truffier-Boutry D, Devaux J, Leloup G. Volume contraction in photocured dental resins: the shrinkage-conversion relationship revisited. *Dent Mater*. 2006;22(4):359–365. [\[CrossRef\]](#)
- Çoğulu D, Ersin N, Ertuğrul F. Renk, ışınlama mesafesi ve ışınlama süresinin iki farklı kompozit materyalinin yüzey sertliği üzerine etkisinin incelenmesi. *EÜ Diş Hek Fak Derg*. 2007;28(2):187–192.
- Moracho SMS, Özcan M, Amaral R, Valandro LF, Bottino MA. Effect of seating forces on cement–ceramic adhesion micro-tensile bond tests. *Clin Oral Investig*. 2013;17:321–331.
- Kilinc E, Antonson SA, Hardigan PC, Kesercioglu A. The effect of ceramic restoration shade and thickness on the polymerization of light-and dual-cure resin cements. *Oper Dent*. 2011;36(6):661–669. [\[CrossRef\]](#)
- Hekimoğlu C, Anıl N, Etikan I. Effect of accelerated aging on the color stability of cemented laminate veneers. *Int J Prosthodont*. 2000;13(1):29–33.
- Price RB, Dérand T, Loney RW, Andreou P. Effect of light source and specimen thickness on the surface hardness of resin composite. *Am J Dent*. 2002;15(1):47–53.
- Shortall A, Harrington E. Guidelines for the selection, use, and maintenance of visible light activation units. *Br Dent J*. 1996;181(10):383–387. [\[CrossRef\]](#)
- Tate WH, Porter KH, Dosch RO. Successful photocuring: don't restore without it. *Oper Dent*. 1999;24(2):109–114.
- Prati C, Chersoni S, Montebugnoli L, Montanari G. Effect of air, dentin and resin-based composite thickness on light intensity reduction. *Am J Dent*. 1999;12(5):231–234.
- Albino LGB, Rodrigues JA, Kawano Y, Cassoni A. Knoop micro-hardness and FT-Raman evaluation of composite resins: influence of opacity and photoactivation source. *Braz Oral Res*. 2011;25(3):267–273. [\[CrossRef\]](#)
- Öztürk E, Bolay Ş, Hickel R, Ilie N. Effects of ceramic shade and thickness on the micro-mechanical properties of a light-cured resin cement in different shades. *Acta Odontol Scand*. 2015;73(7):503–507. [\[CrossRef\]](#)

21. Watanabe H, Kazama R, Asai T, et al. Efficiency of dual-cured resin cement polymerization induced by high-intensity LED curing units through ceramic material. *Oper Dent*. 2015;40(2): 153–162. [\[CrossRef\]](#)
22. Turp V, Ongul D, Gultekin P, Bultan O, Karataslı B, Pak Tunc EP. Polymerization efficiency of two dual-cure cements through dental ceramics. *J Istanbul Univ Fac Dent*. 2015;49(1):10–18. [\[CrossRef\]](#)
23. Çelik E, Göktepe B. Optical properties of novel resin matrix ceramic systems at different thicknesses. *Cumhuriyet Dent J*. 2019;22(2):176–184. [\[CrossRef\]](#)
24. Turp V, Sen D, Poyrazoglu E, Tuncelli B, Goller G. Influence of zirconia base and shade difference on polymerization efficiency of dual-cure resin cement. *J Prosthodont*. 2011;20(5):361–365. [\[CrossRef\]](#)
25. Puppin-Rontani RM, Dinelli RG, de Paula AB, Fucio SBP, Ambrosano GMB, Pascon FM. In-depth polymerization of a self-adhesive dual-cured resin cement. *Oper Dent*. 2012;37(2):188–194. [\[CrossRef\]](#)
26. Choi GY, Park JK, Jin MU, Kwon YH, Son SA. Influence of resin-nanoceramic CAD/CAM block shade and thickness on the microhardness of dual-cured resin cement. *Korean J Dent Mat*. 2017;44(2):151–161. [\[CrossRef\]](#)
27. Öztürk E, Hickel R, Bolay S, Ilie N. Micromechanical properties of veneer luting resins after curing through ceramics. *Clin Oral Investig*. 2012;16(1):139–146. [\[CrossRef\]](#)
28. Caprak YO, Turkoglu P, Akgungor G. Does the translucency of novel monolithic CAD/CAM materials affect resin cement polymerization with different curing modes? *J Prosthodont*. 2019;28(2):e572–e579. [\[CrossRef\]](#)