REVISTA CIÊNCIAS e ODONTOLOGIA

INFLUENCE OF THE CERAMIC TRANSLUCENCY ON THE CONVERSION DEGREE OF DIFFERENT ADHESIVE SYSTEMS – IN VITRO STUDY

INFLUÊNCIA DA TRANSLUCIDEZ CERÂMICA NO GRAU DE CONVERSÃO DE DIFERENTES SISTEMAS ADESIVOS – ESTUDO IN VITRO

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Resumo

Introdução: A crescente exigência estética, aliada à evolução dos materiais restauradores, tem levado ao uso crescente de restaurações cerâmicas livres de metal na reabilitação oral. **Objetivo:** Este estudo avaliou o grau de conversão (%DC) de diferentes sistemas adesivos curados através de cerâmicas com diferentes translucidezes. **Métodos:** Foram medidos os %DC de três adesivos: SBU - Scothbond Universal (3M ESPE), AMB - Ambar (FGM), APS - Ambar APS (FGM), considerando duas translucidezes cerâmicas: alta (HT) e baixa (LT). Uma amostra de cerâmica padrão (10 mm x 10 mm x 1 mm) foi obtida de cada translucidez testada. Um cimento resinoso translúcido padrão (Variolink Esthetic LC, Ivoclar Vivadent) foi colocado sobre um lado de cada amostra de cerâmica para simular a interface do cimento. A medição do %DC do adesivo foi feita por espectroscopia FTIR, considerando a relação entre ligações duplas de carbono alifático/aromático antes e depois da cura através da amostra cerâmica. Foram feitas cinco leituras para cada adesivo. Os dados foram submetidos à análise de variância a dois critérios (Anova Two-Way) e teste de Tukey (p<0,05). **Resultados**: Houve diferença estatística para o adesivo (p<0,001) e interação cerâmica x adesivo (p=0,035), enquanto para a cerâmica não houve diferença significativa (p=0,903). Para as duas cerâmicas, o adesivo APS apresentou o maior valor de %DC, seguido pelo AMB e SBU. **Conclusão:** Para cerâmicas com 1 mm de espessura a translucidez teve baixa influência no %DC do adesivo. O adesivo contendo o sistema APS apresentou melhor conversão de monômeros comparado aos demais testados.

Palavras-Chave: Adesivos; Cerâmica; Fotoiniciadores; Fotopolimerização; Translucidez.

Abstract

Introduction: The increasing aesthetic demand, combined with the evolution of restorative materials, has led to the growing use of metal-free ceramic restorations in oral rehabilitation. **Objective:** This study evaluated the degree of conversion (%DC) of different adhesive systems cured through ceramics with different translucencies. **Methods:** The %DC of three adhesives was measured: SBU - Scothbond Universal (3M ESPE), AMB - Ambar (FGM), APS - Ambar APS (FGM), considering two ceramic translucencies: high (HT) and low (LT). A standard ceramic sample (10 mm x 10 mm x 1 mm) was obtained from each translucency tested. A standard translucent resin cement (Variolink Esthetic LC, Ivoclar Vivadent) was placed over one side of each ceramic sample to simulate the cement interface. The measurement of the adhesive %DC was made using FTIR spectroscopy, considering the ratio of aliphatic/aromatic double carbon bonds before and after curing through the ceramic sample. Five readings were made for each adhesive. Data were subjected to two-way analysis of variance (Anova Two-Way) and Tukey test (p <0.05). **Results:** There was a statistical difference for the adhesive (p <0.001) and ceramic x adhesive interaction (p = 0.035), while for the ceramic, there was no significant difference (p = 0.903). For the two ceramics, the APS adhesive had the highest %DC value, followed by AMB and SBU. **Conclusion**: For ceramics with 1 mm thickness, the translucency had a low influence on the %DC of the adhesive. The adhesive containing the APS system showed better conversion of monomers compared to the others tested.

Keywords: Adhesives; Ceramics; Photoiniciators; Photopolimerization; Translucency.

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Introduction

The increasing aesthetic demand added to the evolution of restorative materials has made metal-free ceramic restorations increasingly used in oral rehabilitation[2]. Ceramics, such as lithium disilicate, associate favorable physical characteristics, such as high mechanical strength and aesthetics, with the ability to adhere to dental substrates through resin cement and even flowable composites[2,16,25]. In this context, ceramic veneers have gained popularity in Restorative Dentistry due to their high aesthetic capacity, resistance, and conservative characteristics[7,14,26]. Studies report a clinical survival rate for ceramic veneers greater than 90% for 5 years, and between 60% and 90% for 10 years of evaluation[1], and it is estimated that the success of these treatments is directly related to the cementation stage[6].

Adhesive cementation of ceramic restorations involves conditioning the dental surfaces and the prosthetic piece with acids that aim to increase the retention of the pieces and/or the wettability of the surfaces by the adhesives, thus favoring the union with the resin cement[5]. The adhesive interface is responsible for ensuring homogeneous stress distribution between the restorative material and the tooth structure[20], and usually, for ceramic veneers, light-cured materials are preferred due to control of working time and color stability[7] when compared to chemical systems.

The thickness, composition, and color of the ceramic[12,15,20] as well as the light source used for light-curing[21], can affect the degree of conversion of the resin cement used in adhesive procedures, as they change the amount of light that reaches the material. Concerning the ceramic features, high translucency, low thickness, and shades A1 and A2 were associated with higher light transmission[19]. The attenuation of the light by ceramic may be compensated considering the concept of the energy density which is the product of the total intensity emitted by the exposure time[23].

Usually, the assessment of the degree of conversion of resin cement is considered in the evaluation of the ability to convert monomers into polymers in these studies; however, many times, during the cementation of ceramic pieces, the adhesive is applied to the dental substrates and its piece with the cement in position so that the polymerization of the set is carried out in a single step. Thus, this study aimed to evaluate the degree of conversion of different adhesive systems used in the cementation of ceramic veneers and the influence of the translucency of the ceramic in this process.

Materials and Methods

The studied variable of this in vitro analysis was the conversion degree (%DC) measured by FTIR spectroscopy of the following adhesive systems: SBU - Scothbond Universal (3M ESPE, USA), AMB - Ambar (FGM Dental Group, Brazil) and APS- Ambar APS (FGM Dental Group, Brazil). Their composition is listed in Table 1.

Table 1 – Composition of the adhesive system tested.

Adhesive	Composition
***SBU* - Scothbond Universal (3M ESPE)**	Phosphate monomer (MDP), dimethacrylate resins, filler, HEMA, Vitrebond™ copolymer, alcohol, water, initiators, silane.
***AMB* – Ambar (FGM Dental Group)**	MDP, Methacrylic monomers, photoinitiators, co-initiators, stabilizers, inert fillers (silica nanoparticles), and ethanol
***APS* – Ambar APS (FGM Dental Group)**	MDP, methacrylic monomers, photoinitiating composition (APS - Advanced Polymerization System), co-initiators, stabilizer, silica nanoparticles, and ethanol

The conversion degree (%DC) of each adhesive was measured considering two translucencies of lithium disilicate ceramic (E-max, Ivoclar Vivadent, Schaan, Liechtenstein): high (HT) and low (LT) translucency. For that, one standard specimen of each ceramic was obtained from E.max ceramic blocks (Ivoclar Vivadent) with help of a precision cut machine (IsoMet 1000, Buehler, Illinois, USA) (Figure 1). Both samples had the following dimensions: 10 mm (width) x 10 mm (length) x 1 mm (thickness), being one of high translucency (HT – Shade A2) and other of low translucency (LT – Shade A2). At one side of each sample, a thin layer of resin cement was placed (Variolink Esthetic LC, Ivoclar Vivadent) to mimic the cement interface and standardized at 0.3 mm (Figure 1).

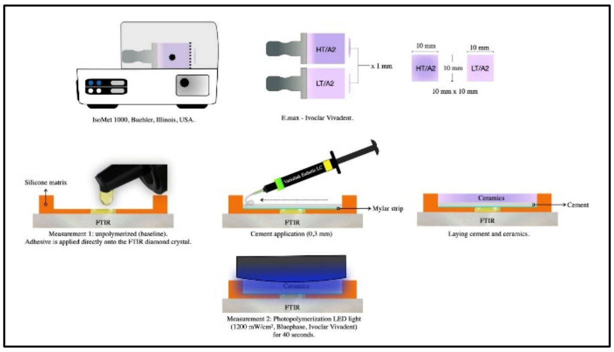

Figure 1 – schematic drawing of the experiment

The conversion degree (%DC) of the adhesive systems was assessed using a Fourier transform infrared (FTIR) spectrophotometer (Spectrum Spotlight 400, Perkin Elmer). The standard volume of the adhesive from each group was placed directly on the equipment's diamond crystal platform. The following parameters were adopted in all measurements: spectra collected from 4000 cm-1 to 1500 cm-1, with 32 scans, 2 spectrum per second, at a resolution of 4cm-1. Immediately after placing the adhesive over the equipment crystal, a mylar strip was placed over it, and the first reading was made as baseline. Then the set cement/ceramic was placed over it, followed by photopolymerization using LED light (1200 mW/cm², Bluephase, Ivoclar Vivadent) for 40 sec. After the cure, a new spectra reading was made using the same parameters. Five readings were made for each adhesive and each ceramic translucency.

The height (H) under the peak at 1638 cm-1 represented the vinyl C=C groups of the adhesive, while the height under the peak at 1608 cm-1 represented the aromatic C=C and both measures served as the internal standard (Figure 2). The %DC was calculated using the formula: %DC = [1–(H1638/H1608 polymerized) / (H1638/H1608 unpolymerized)] x 100.

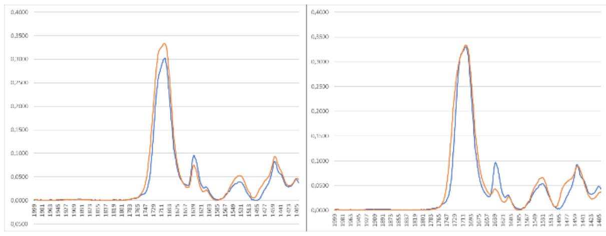

Figure 2 – On the left, spectrum of the Ambar adhesive before (blue line) and after polymerization (orange line) with a completely opaque metallic matrix only to show both lines almost overlapping and indicating absence of polymerization of the adhesive. On the right, the same adhesive with the cement and low translucency ceramic set used, showing the orange curve (after polymerization) much smaller than the blue one (without polymerization) in the region of the 1638cm-1 band indicating polymerization of the adhesive.

Data was analyzed regarding normal distribution (Kolmogorov Smirnov test) and then submitted to analysis of variance (ANOVA 2-way) followed by Tukey test, considering values of $p < 0.05$ as statistically significant. The analysis was made with the Jamovi software (v. 1.8 - The jamovi project - 2021).

Results

The ANOVA two-way test was used to compare both studied factors – ceramics and adhesives. For the ceramics, there were no significant differences between the LT and HT (value of $p = 0.600$), indicating that the translucency of thin ceramic layers does not influence the conversion degree of the adhesive. For the adhesives tested, there was a significant difference between them, with p value $p < 0.001$ (thus, statistically significant), and the Tukey test showed that the adhesive APS presented the highest conversion degree value, followed by AMB and SBU, respectively. Table 2 shows the results of the ANOVA test and the result of the Tukey test for the adhesive factor and the interaction of the factors.

Table 2 – Mean and standard deviation of the degree of conversion for the adhesives and ceramics tested and results of the Tukey test for the

adhesive factor and Tukey test for the interaction between the factors.

	Ceramics LT		Ceramics HT		
	Mean	DP	Mean	DP	Tukey Test
Amb	41.66	0.48	41.93	0.34	B
APS	50.02	3.45	51.96	2.62	A
SBU	34.64	4.33	37.81	4.84	C

Capital letters show the difference between the rows for the adhesive factor. There was no difference between the ceramics (p=0.600)

Discussion

The findings of this study highlight the critical influence of adhesive composition on the degree of conversion (%DC), particularly concerning the photoinitiator system employed. Among the tested adhesives, the one containing the APS photoinitiator system (Ambar APS) demonstrated a significantly higher %DC compared to the adhesives containing only camphorquinone (SBU and Ambar), regardless of the ceramic translucency. According to the manufacturer, the APS system (Advanced Polymerization System – FGM Dental Group) incorporates lower concentrations of camphorquinone in combination with alternative photoinitiators capable of enhancing the absorption and utilization of light energy. This synergistic effect promotes more efficient activation of monomers and contributes to a higher polymerization rate. The superior performance of Ambar APS, particularly when compared to the conventional Ambar adhesive—which shares a similar resin matrix composition but lacks the APS system—underscores the relevance of the initiator system in optimizing polymerization through ceramic restorations. Additionally, the reduced camphorquinone content in Ambar APS confers greater translucency to the adhesive layer, minimizing the potential for discoloration at the ceramic-adhesive interface, as previously reported by Oliveira Junior (2019)[17]. From a clinical standpoint, the incorporation of the APS system may enhance the performance of adhesive procedures, mainly under moist conditions, as its more hydrophilic photoinitiators mitigate the incompatibility between hydrophobic camphorquinone and the hydrophilic environment of acid-etched, such as dentin, which the substrate often in contact with the adhesive during cementation procedures. This characteristic facilitates improved monomer infiltration and polymerization in oversaturated substrates, potentially contributing to more stable and durable adhesive interfaces.[17]

Regarding the SBU, although studies show great performance in bonding to tooth substrates[11,13,18,22], in this study, it was the adhesive with the lowest %DC values. A possible explanation might be the association of water/ethanol used as solvent in this adhesive (Table 1), compared with only the ethanol from the APS and AMB. Clinically, the solvents should be completely removed with an air-blast to avoid the dilution of the monomers and the formation of voids, to increase the permeability of the cured adhesive layer, and to attain a high cross-linking polymer[3,8,9]. During the execution of the measurements, the solvent evaporation was not performed to avoid its removal from the surface of the spectrophotometer's crystal. This decision was made following the results of described by Carvalho et al (2019)[3] which showed that both SBU and AMB are less influenced by evaporation methods, although clinically this step should be performed.

Concerning ceramic translucency, although previous studies have indicated that the shade, thickness, and translucency of lithium disilicate glass ceramics can influence the degree of conversion (%DC) of resin cements [10,20], the present results suggest that when thin ceramic veneers are used—up to 1 mm in thickness—light transmission is sufficient to adequately polymerize the underlying adhesive layer. This finding supports the clinical use of light-cured resin cements or even flowable composites for veneer cementation, minimizing the need for dual-cure or self-cure systems, which are often associated with lower color stability due to the degradation of tertiary amines[17]. Furthermore, no significant difference was observed between high and low translucency ceramics regarding adhesive conversion, indicating that both levels of translucency allow adequate light transmission through 1 mm thickness. Nevertheless, it is essential to emphasize that achieving optimal monomer conversion for both adhesives and resin cements requires the use of a high-quality light-curing unit, with appropriate irradiance, total energy dose, and a homogeneous light beam profile[23].

The evaluation of the conversion degree in dental composition is frequently performed and reported in the literature as a predictor of the quality and longevity of the composite material[4]. It is expected that higher monomer conversion creates restorative materials and bonding interface with a higher degree of cross-links, thus more resistant to physical and chemical degradation, although it is not always evident that there is a direct relationship between %DC and bonding performance[4,24]. Therefore, the results of this study shall be carefully analyzed, and future studies should evaluate the bond strength and aging process over the adhesive interface when the adhesive system is cured concomitant to the resin cement for veneer cementation.

Conclusion

Within the limitations of this study, it can be concluded that, for ceramics with a thickness of 1 mm, the degree of translucency has a low influence on the conversion degree of the adhesive used in the tooth substrate. This suggests that, clinically, the translucency of thin ceramic veneers does not impact on the performance of the adhesive use in the cementation process but needs to be validated in clinical trials. Regarding the adhesive, the one containing the APS system showed better conversion of monomers compared to the other adhesives tested when cured through a ceramic veneer. This might suggest better bonding performance of this adhesive clinically but needs confirmation by clinical trials.

References

1. Beier US, Kapferer I, Burtscher D, Dumfahrt H. Clinical performance of porcelain laminate veneers for up to 20 years. Int J Prosthodont. 2012;25(1):79–85.
2. Della Bona A, Nogueira AD, Pecho OE. Optical properties of CAD–CAM ceramic systems. J Dent. 2014;42(9):1202–9. doi: 10.1016/j.jdent.2014.07.005.
3. Carvalho CN, Lanza MDS, Dourado LG, Carvalho EM, Bauer J. Impact of Solvent Evaporation and Curing Protocol on Degree of Conversion of Etch-and-Rinse and Multimode Adhesives Systems. Int J Dent. 2019;2019:1–6. doi: 10.1155/2019/5496784.
4. David-Pérez M, Ramírez-Suárez JP, Latorre-Correa F, Agudelo-Suárez AA. Degree of conversion of resin-cements (light-cured/dual-cured) under different thicknesses of vitreous ceramics: systematic review. J Prosthodont Res. 2022;66(3):JPR_D_20_00090. doi: 10.2186/jpr.JPR_D_20_00090.
5. Faria-e-Silva AL, Pfeifer CS. Development of dual-cured resin cements with long working time, high conversion in absence of light and reduced polymerization stress. Dental Materials. 2020;36(10):e293–301. doi: 10.1016/j.dental.2020.06.005.
6. Gresnigt MMM, Özcan M, Carvalho M, Lazari P, Cune MS, Razavi P, et al. Effect of luting agent on the load to failure and accelerated-fatigue resistance of lithium disilicate laminate veneers. Dental Materials. 2017;33(12):1392–401. doi: 10.1016/j.dental.2017.09.010.
7. Haralur SB. Microleakage of porcelain laminate veneers cemented with different bonding techniques. J Clin Exp Dent. 2018;10(2):e166–71. doi: 10.4317/jced.53954.
8. Ikeda T, De Munck J, Shirai K, Hikita K, Inoue S, Sano H, et al. Effect of air-drying and solvent evaporation on the strength of HEMA-rich versus HEMA-free one-step adhesives. Dental Materials. 2008;24(10):1316–23. doi: 10.1016/j.dental.2008.02.009.
9. Klein-Júnior CA, Zander-Grande C, Amaral R, Stanislawczuk R, Garcia EJ, Baumhardt-Neto R, et al. Evaporating solvents with a warm air-stream: Effects on adhesive layer properties and resin–dentin bond strengths. J Dent. 2008;36(8):618–25. doi: 10.1016/j.jdent.2008.04.014.
10. Liporoni P, Ponce A, de Freitas M, Zanatta R, Pereira M, Catelan A. Influence of thickness and translucency of lithium disilicate ceramic on degree of conversion of resinous materials. J Clin Exp Dent. 2020;e745–8. doi: 10.4317/jced.56921.
11. Lorenzoni e Silva F, Pamato S, Kuga M, So M, Pereira J. Bond strength of adhesive resin cement with different adhesive systems. J Clin Exp Dent. 2016;0–0. doi: 10.4317/jced.53099.
12. Mendonça LM De, Ramalho IS, Lima LASN, Pires LA, Pegoraro TA, Pegoraro LF. Influence of the composition and shades of ceramics on light transmission and degree of conversion of dual-cured resin cements. Journal of Applied Oral Science. 2019;27doi: 10.1590/1678-7757-2018-0351.

13. Michaud P-L, Brown M. Effect of universal adhesive etching modes on bond strength to dual-polymerizing composite resins. J Prosthet Dent. 2018;119(4):657–62. doi: 10.1016/j.prosdent.2017.06.018.
14. Nikzad S, Azari A, Dehgan S. Ceramic (Feldspathic; IPS Empress II) vs. laboratory composite (Gradia) veneers; a comparison between their shear bond strength to enamel; an in vitro study. J Oral Rehabil. 2010;37(7):569–74. doi: 10.1111/j.1365-2842.2009.02052.x.
15. Novais VR, Raposo LHA, Miranda RR de, Lopes C de CA, Simamoto Júnior PC, Soares CJ. Degree of conversion and bond strength of resin-cements to feldspathic ceramic using different curing modes. Journal of Applied Oral Science. 2017;25(1):61–8. doi: 10.1590/1678-77572016-0221.
16. Oh S, Shin S-M, Kim H-J, Paek J, Kim S-J, Yoon TH, et al. Influence of glass-based dental ceramic type and thickness with identical shade on the light transmittance and the degree of conversion of resin cement. Int J Oral Sci. 2018;10(1):5. doi: 10.1038/s41368-017-0005-7.
17. Oliveira Jr OF de, Kunz PVM, Baratto Filho F, Correr GM, Cunha LF da, Gonzaga CC. Influence of Pre-Curing Different Adhesives on the Color Stability of Cemented Thin Ceramic Veneers. Braz Dent J. 2019;30(3):259–65. doi: 10.1590/0103-6440201902369.
18. Passia N, Lehmann F, Freitag-Wolf S, Kern M. Tensile bond strength of different universal adhesive systems to lithium disilicate ceramic. The Journal of the American Dental Association. 2015;146(10):729–34. doi: 10.1016/j.adaj.2015.04.008.
19. Pereira CN de B, Magalhães CS de, Daleprane B, Peixoto RTR da C, Ferreira R da C, Cury LA, et al. LED and Halogen Light Transmission through a CAD/CAM Lithium Disilicate Glass-Ceramic. Braz Dent J. 2015;26(6):648–53. doi: 10.1590/0103-6440201300367.
20. Pereira CB, Magalhães C, Lages F, Ferreira RC, da Silva E, da Silveira R, et al. Degree of conversion and microhardness of resin cements photoactivated through glass ceramic. J Clin Exp Dent. 2021;e1068–75. doi: 10.4317/jced.58630.
21. Ramos R, Moraes R, Lopes G. Effect of LED Light-Curing Spectral Emission Profile on Light-Cured Resin Cement Degree of Conversion. Oper Dent. 2021;46(1):63–74. doi: 10.2341/19-234-L.
22. Rohr N, Flury A, Fischer J. Efficacy of a Universal Adhesive in the Bond Strength of Composite Cements to Polymer-infiltrated Ceramic. J Adhes Dent. 2017;19(5):417–24. doi: 10.3290/j.jad.a39277.
23. Rueggeberg FA, Giannini M, Arrais CAG, Price RBT. Light curing in dentistry and clinical implications: a literature review. Braz Oral Res. 2017;31(suppl 1)doi: 10.1590/1807-3107bor-2017.vol31.0061.
24. De Souza G, Braga RR, Cesar PF, Lopes GC. Correlation between clinical performance and degree of conversion of resin cements: a literature review. Journal of Applied Oral Science. 2015;23(4):358–68. doi: 10.1590/1678-775720140524.
25. Warreth A, Elkareimi Y. All-ceramic restorations: A review of the literature. Saudi Dent J. 2020;32(8):365–72. doi: 10.1016/j.sdentj.2020.05.004.
26. Zhao K, Pan Y, Guess PC, Zhang X-P, Swain M V. Influence of veneer application on fracture behavior of lithium-disilicate-based ceramic crowns. Dental Materials. 2012;28(6):653–60. doi: 10.1016/j.dental.2012.02.011. .