Cumhuriyet Dental Journal, 25(Suppl/2): 38-45, 2022
DOI: https://doi.org/10.7126/cumudj.1187835

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 | Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 | Publisher: Sivas Cumhuriyet Üniversitesi

Examination of the Shear Force Resistance of Laminate Veneers Adhered with Different Resin Cements

Zeynep Yeşil Duymuş[1-a], Emel Arslan[2-b*]

[1] *Department of Prosthodontic, Faculty of Dentistry, Atatürk University, Erzurum, Türkiye.*

[2] *Department of Prostodontic, Faculty of Dentistry, Bolu Abant Izzet Baysal University, Bolu, Türkiye*

**Corresponding author*

Research Article

Acknowledgment

This study was presented as an oral presentation at the ''Sivas Cumhuriyet University 2st International Dentistry Congress'' held between 22-24 September 2022.

History

Received: 12/10/2022
Accepted: 27/12/2022

ABSTRACT

Objectives: *This study investigated the mechanical properties of laminate veneers to determine their resistance to the shear force of three different types of cement used in the restorations.*

Materials and Methods: *Laminate veneers were prepared using standard tooth preparation methods for 30 extracted maxillary central incisors. To standardize the depth, guide burs were used to prepare a depth of 0.5 mm from the buccal angle. The samples were allocated into three randomized groups (n = 10): Group A (resin using the total etch method and Variolink Esthetic DC resin cement), Group B (resin using the PANAVIA F2.0 self-etch method), and Group C (self-adhesion bonded with Rely X U200 resin cement). The prepared specimens were stored in distilled water for one week before being thermal cycled for 500 cycles in 5°C and 55°C water. A shear test was used to determine the resistance of the veneers to the bonding. The obtained data were evaluated statistically.*

Results*: The values of the shear bond strength were statistically significant depending on the type of resin cement used ($p < 0.05$). The specimens that were cemented using the total-etch method had the lowest shear force value (18.79 ± 4.48 MPa). The obtained data were statistically evaluated using the Tukey multiple comparison test ($p > 0.05$).*

Conclusions: *The type of cement is a highly effective factor in the bonding between fixed prosthetic restorations and the abutment tooth, and the cement used must have sufficient resistance to shear forces.*

Keywords: *Laminate veneer, Shear strength, Resin cement.*

Değişik Rezin Simanlarla Yapıştırılan Laminate Veneerlerin Makaslama Kuvvetine Karşı Dirençlerin İncelenmesi

Bilgi

 # Bu çalışma 22-24 Kasım 2022 tarihleri arasında düzenlenen 'Sivas Cumhuriyet Üniversitesi 2. Uluslararası Diş Hekimliği Kongresi'nde sözlü bildiri olarak sunulmuştur.

Süreç

Geliş: 12/10/2022
Kabul: 27/12/2022

ÖZ

Amaç: *Kullanılan simanların mekanik özelliklerinin bilinmesi restorasyonların başarısı için önemlidir. Bu çalışmanın amacı; laminate veneerlarde kullanılan simanların makaslama kuvvetine karşı dirençlerinin incelenmesidir.*

Gereç ve Yöntemler: *Çalışmada 30 adet herhangi çürük ve restorasyon olmayan çekilmiş maksiller santral diş standart bir şekilde prepare edildikten sonra IPS e.max Press (Ivoclar) laminate veneerlar hazırlandı. Derinliği standardize etmek için bukkal açıdan 0,5 mm'lik bir derinlik hazırlamak için derinlik kılavuz frezi kullanıldı. Rasgele olacak şekilde dişler üç gruba ayrılarak (n=5); Grup A: Total etch yöntemi kullanılarak Variolink Esthetic DC (Ivoclar Vivadent) rezin, Grup B: Self etch yöntemi kullanılarak Panavia F2.0 (Kuraray) rezin, Grup C: Self adeziv RelyX U200 (3M ESPE) rezin simanla preparasyon yapılan dişlere simante edildi. Simantasyon işleminden sonra 1 hafta distile suda bekletip 5 ile 55 °C suda 500 döngü termal siklus işlemine tabi tutularak makaslama testi ile bağlanma dirençleri değerlendirildi. Elde edilen veriler Tukey çoklu karşılaştırma testi ile istatiksel olarak değerlendirildi.*

Bulgular: *Çalışmada kullanılan rezin simanların, makaslama kuvvetlerinin karşı dirençlerinin anlamlı farklılık ($p<0.05$) gösterdiği istatistiksel olarak saptandı. En düşük makaslama kuvveti değeri; Total-etch ile simante edilen örneklerde (18.79±4.48 MPa) elde edildi. Self-etch ve self adeziv yöntem ile restore edilen örneklerde anlamlı fark ($p>0.05$) görülmedi.*

Sonuçlar: *Sabit protetik restorasyonlar ve dayanak diş arasındaki bağlantıda siman son derece etkili bir faktör olup, kullanılan simanın makaslama kuvvetlerine karşı yeterli direnç göstermesi gerekir.*

Anahtar Kelimeler: *Laminate veneer, Makaslama kuvveti, Rezin siman.*

[a] *zeynep.yesilduymus@erdogan.edu.tr* *https://orcid.org/0000-0002-9767-0080* [b] *emel.arslan08@outlook.com* *https://orcid.org/0000-0002-9319-5972*

How to Cite: Yeşil Duymuş Z, Arslan E. (2022) Examination of the Shear Force Resistance of Laminate Veneers Adhered with Different Resin Cements, Cumhuriyet Dental Journal, 25(Suppl/2):38-45.

Introduction

Advances in technology and research on new dental materials have provided a solution for the aesthetic and biological incompatibilities created by metal infrastructures.[1,2] These studies have improved the physical properties of the materials and their clinical success has enabled all-ceramic materials to play a significant role in standard restoration treatments.[3] Common dental problems include disturbances in tooth structure, misalignment of teeth, and discoloration or tooth loss. In recent years, there has been an increase in the use of aesthetic dentistry treatments in the anterior region of the mouth. Laminate veneers, which improve aesthetics with a conservative approach, have become very popular.[4] The main advantages of the laminate veneer technique are enhanced aesthetics, biological compatibility, minimal preparation requirements, and high bond strength. However, laminate veneers are fragile and difficult to repair, require technical skill, are expensive, and the porcelain can crack or break when chewing hard foods.[5,6]

In the laminate veneer technique, the lifespan of the restoration depends on the material used and the physical properties of the cement. The most important criterion for the long-term success of restorations is the connection it makes with the abutment tooth. Resin cements have become the preferred choice for cementing ceramic restorations due to their aesthetic appearance and superior bonding properties.[7]

In adhesive cementation applications, pre-treatment of dental tissue is required. Different cement application techniques can be used, including acid etching, primer and adhesive (total-etch method), or only primer and adhesive (self-etch method). Adhesive applications in the cementation stage complicate the application techniques of these cements, limiting their use.[8] In recent years, self-adhesive universal resin cements that do not require primer and adhesive applications, eliminating the acid etching process and reducing technical sensitivity, have been used for the convenience of the clinician.[9]

In dentistry, different methods are used to evaluate the effect of adhesives. While clinical trials are the most effective method, in vitro bond strength tests are often used because long-term follow-up in clinical trials is time-consuming and difficult to perform. Bond strength tests are used to measure the minimum force required to disrupt the bond between the adhesive and the adherent, causing failure.[10]

In this study, the resistance of laminate veneer specimens to the shear force of resin cements was examined to determine bonding strength. To do this, an appliance was prepared that applies an equal amount of force to the tooth surface and porcelain, opposite and parallel to each other.

The appliance is designed to prevent rotational force.[11]

The laminate veneer restorations prepared for this study were stored in distilled water after bonding with different resin cements, and their shear strength was examined. The null hypothesis of the study is: the restorations are formed in such a way that the shear force of the cement used does not affect them.

Materials and Methods

In the study, 30 maxillary central incisor teeth without caries or restorations were used. The G *Power package program (G *Power Ver. 3.0.10, Franz Faul, Universität Kiel, Germany) was used to determine the number of teeth needed for the study. It was determined that a total of 30 teeth should be used for 80% power at 25% effect size with $\alpha = 0.05$ type 1 error rates. The Atatürk University ethical committee gave its consent to use the extracted teeth. The mean incisocervical and mesiodistal lengths of all the selected teeth were 8 mm. After extraction, the teeth were kept in a 0.5% thymol solution until use. The teeth were stored in the same environment for similar periods of time.

Preparation of the Specimens

After removing all hard and soft tissue residues from the tartar on the teeth, markings were made 1 mm below the cervical line and wax was placed around this line to ensure that the enamel of the teeth was not dipped into the acrylic. The teeth were embedded in a silicone mold using a parallelometer (Kavo EWL, Type 990, Kavo Elektrotechnisches Werk GmbH, Leutkirch, Germany). The teeth were then vertically embedded in autopolymerizing acrylic resin (Imicryl SC, Imicryl, Konya, Turkiye) using a parallelometer. Acrylic resin was prepared according to the manufacturer's recommendations and poured into a silicone mold. After hardening, the teeth were removed from the mold and the acrylic resin was polished.

Preparation of the Teeth

To begin preparing the teeth, guide grooves were made. To standardize the depth, the depth was set to 0.5 mm from the buccal angle using guide burs. The grooves were then marked with a pencil to achieve a controlled groove depth. The preparation continued with a chamfer bur. The incisal edge was measured and marked with a 1 mm caliper (Figure 1) and prepared as a butt-joint. The marginal preparation was completed using a chamfer bur according to the shape of the bur. Proximal contact points were prepared to be palatal. Then, a polishing disc was used to make the teeth smoother.

Surface Preparation of the Restorations

After preparing the 30 maxillary central incisor teeth, lithium disilicate ceramic (MT E.max Press A2; Ivoclar Vivadent, Schaan, Liechtenstein) laminate veneers were applied. Laminate veneer specimens 0.5 mm thick were prepared separately for each tooth

(Figure 2). The thickness of each sample was checked with a digital caliper. After the laminate veneer samples were glazed, 9.5% hydrofluoric acid (Ultradent Porcelain Etch, Ultradent Products, Köln, Germany) was applied to the non-glazed surface for 20 seconds. The samples were then washed with air and water spray for 20 seconds and dried. The samples were treated with silane (Monobond Plus, Ivoclar Vivadent) for 60 seconds.

Cementation of the Restorations

After preparing the specimens, they were randomly allocated into three groups based on the cement type (n = 10) (Table 1) as follows:

Group A: The specimens in this group were cemented using the total-etch method. To do this, 37% phosphoric acid was applied for 30 seconds (K-Etchant, Kuraray Medical Co., Tokyo, Japan) and the specimens were air-washed using water spray. The prepared surface of the teeth was treated with an adhesive bonding agent (Adherse Universal bonding agent Ivoclar, Vivadent) for 20 seconds. The specimens were air-dried for 5 seconds and then light-cured for 10 seconds according to the manufacturer's instructions. Variolink Esthetic DC (VE-DC) resin cement (Ivoclar Vivadent) was applied homogeneously and the excess was cleaned. Cementation was completed by light-curing each surface for 10 seconds.

Group B: A 37% phosphoric acid gel was applied to the enamel and dentin of the self-etch-cemented specimens for 15 seconds, then they were washed and air-dried. PANAVIA F2.0 (PF) resin cement (Kuraray, Osaka, Japan) was mixed with one drop each of primer A and primer B, and then applied to the surface of each tooth and air-dried. The resin cement, produced as two fabricated tubes, was mixed in equal amounts and the restoration was bonded to each tooth. After removing the excess, each surface was polymerized by irradiation for 10 seconds.

Group C: The specimens in this group were cemented using Rely X U200 (RX) self-adhesive (3M ESPE Dental Products, St. Paul, MN) without any treatment to the teeth. After cleaning the excess, the surface of the teeth was light-cured for 10 seconds.

Shear Strength Value of the Restorations

After cementation, the laminate veneer samples were stored in distilled water for one week before being thermal cycled for 500 cycles in 5°C and 55°C water and using a shear test to measure the bond strengths. The test was applied in accordance with the requirement of the universal test (Instron) for shear testing. A knife-shaped metal tip was placed parallel to the interface between the restoration and the tooth (Figure 3). The maximum force value when the restorative material was separated from the tooth surface was measured in Newtons (N). A force of 500 N was applied at a speed of 0.5 mm/min.

Statistical Analysis

The Jamovi (Version 1.0.4) computer software application (https://www.jamovi.org) was used for statistical analysis. The Shapiro-Wilk test was used to determine whether the data were normally distributed. ANOVA was used to measure the variations in shear bond strength due to normal distribution. The Tukey's post-hoc test was used to analyze significant differences ($p = 0.05$).

Results

This study investigated the effect of different resin cements on laminate veneers. It was found that the applied composite resins had a statistically significant effect on the shear strength values ($p < 0.05$) (Table 2). When the average shear strength values of the specimens were examined, the lowest value was obtained in the specimens cemented with the total-etch (VE-DC) resin (18.79±4.48 MPa). No significant differences in the shear bond strength values were observed between the self-etch (PF) (26.57± 10.21 MPa) and self-adhesive (RX) (25.96 ± 8.08 MPa) resin cements ($p > 0.05$) (Figure 4). The specimens that were cemented using the self-etch method had the highest shear bond strength value.

Discussion

This study evaluated the mechanical properties of different resin cements used to restore laminate veneer restorations. While there was no statistically significant difference between the self-adhesive cement and self-etch cement among the types of cement used, the total-etch cement had a lower shear strength value. The study's null hypothesis was rejected.

Although it is questionable to use in vitro bond strength tests to determine the clinical effects of dental adhesives, they are used because clinical determination of the mechanical properties of these adhesives is difficult and time-consuming.[12] The shear test used in studies also provides information about the material. Although a shear test has some disadvantages, it also has advantages, such as an easy application procedure and minimal equipment requirement.[11] According to scientific documents from Ivoclar Vivadent, the shear strength of VE-DC resin cement in combination with Adhese Universal using UltraTester is around 20 MPa.[13-15] While this value is suitable for Variolink adhesive system shear strength tests, the results may differ when the analysis methods are different.16 In the present study, a shear strength value < 20 MPa was found. The results may not be the same as those reported in other studies due to differences in the methods applied. However, there is no standard method for testing shear strength in ceramic restorative materials.

Previous studies reported that strengthened porcelains provide a stronger bond with dentin by

cementation when new adhesive techniques and materials are used; thus, the fracture resistance of teeth increases significantly.[17,18] Lithium crystals in IPS-e.max porcelain significantly increase the resistance to breakage. They also provide resistance to the porcelain by preventing the cracks formed on the surface of the material from moving inward.[13,19] In the present study, IPS-e.max, which is mechanically more advantageous than other porcelains, had the highest shear strength value. One study compared a self-adhesive resin cement containing MDP (SpeedCEM Plus, Ivoclar Vivadent), VE-DC double-cured resin cement, and a primer containing phosphoric acid methacrylate and silane methacrylate, such as Monobond Plus. In bonding to conventional 3Y-TZP zirconia, VE-DC appeared to have a significantly higher bond strength value. In the present study, the VE-DC bond strength was found to be lower than the other two types of cement. This can be explained by the difference in the surface structure between zirconium and lithium disilicate glass ceramics.[20,21]

Other studies examining shear force have reported that failures were predominantly due to mixed application procedures for PF adhesion material.[25,26] Self-etch primers produce a thin hybrid layer by partially removing the smear layer. Although the hybrid layer is important, its thickness and relationship to the adhesion bond are still unclear.[27] Amines have been reduced to prevent color change in self-etch resin cements. The bond strength of autopolymerizing resins may have decreased due to the reduction of amines, which causes a decrease in polymers at the bonding surface.[28] Zhang and Degrange[29] examined how the shear bond strengths of different restorative materials were impacted by total-etch (Variolink), self-etch (Multilink Automix), and self-adhesive (RelyX Unicem, Multilink Sprint, and Maxcem) resin cements. In that study, Maxcem cement had the lowest shear bond strength among the glass ceramic materials, while total-etch and self-etch adhesive resin cements had significantly higher bond strength than self-adhesive resin cement ($p < 0.05$). Unlike the present study, in Zhang and Degrange[29] the lowest value was seen in the samples cemented with VE-DC. This conclusion may have been reached due to the different type of cement used. The bond strength may depend on the different composition, solvent, initiator, viscosity, and wettability of the resin cements used. In a study comparing the bond strengths of PF self-etch and RX self-adhesive resin cements, no significant difference was observed, which is similar to our results.[30] Sokolowski et al.[31] investigated the state of stress through photoelastic analysis of resin cement, one of which was VE-DC and the other was RX, using aging in water. A study examining VE-DC resin cement has shown that it has high solubility due to its ability to absorb water. Similar to the present study, the results of that study were obtained using VE-DC, which has the lowest bond strength value.

The polymerization of the double polymerized resin cement is completed within one week after curing, according to previous studies.[32,33] Therefore, in the present study, bond strength tests were conducted one week after the specimens were prepared, presuming that the resin cement was completely polymerized and had reached its maximum bond strength.

The limitation of the study is that it does not completely mimic the oral environment. A clinical trial may reveal different data from the results of the current study. Therefore, a clinical study is recommended to analyze the effect of resin cements on the longevity of the restoration.

Conclusions

Considering the limitations of the study, the following conclusions can be made:

i. The fact that total-etch resin cement has a lower resistance to shear strength can be attributed to its high solubility in water.

ii. Monomers in self-etch resin cement and self-adhesive resin cement may be effective factors in the connection.

iii. Regardless of the method used in the clinic, cement is an effective factor in the connection between the restoration and the abutment tooth. Since the self-adhesive resin application procedure is easier than the self-etch or total-etch methods, it can be preferred in cementation.

Acknowledgements

The authors thank the Coordinatorship for Scientific Research Projects at Recep Tayyip Erdogan University University for supporting Project TDH-2020-1085.

Conflicts of Interest Statement

The authors do not have any financial interest in the companies whose materials are included in this article.

Figure 1. 1 mm of reduction is measured using a Digital caliper.

Figure 2. According to the tooth surface, a laminate veneer was produced.

Figure 3. The interface shear bond strength between tooth and restoration was applied.

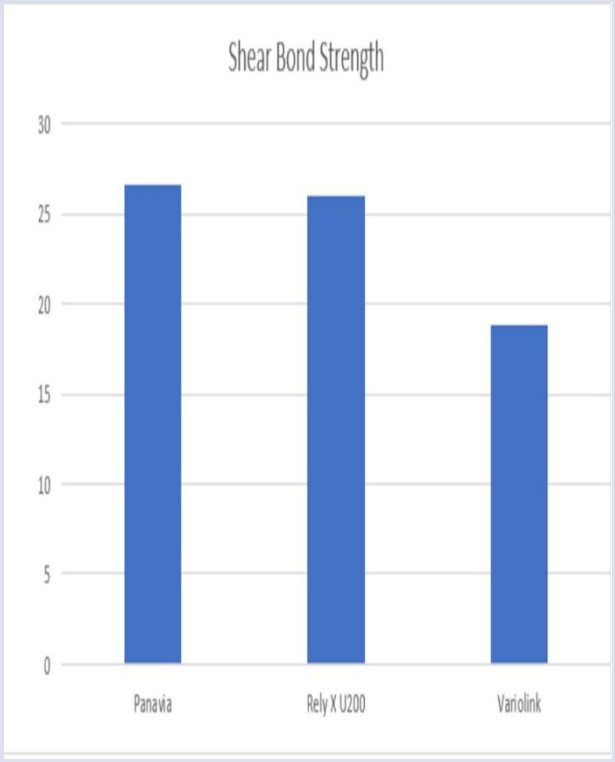

Figure 4. Shear bond strength

Table 1. Compositions of the Resin Cements Used in the Study

Resin cement	Manufacturer	Product batch*	Chemical composotion
Variolink Esthetic DC	Ivoclar Vivadent	Dual-cure (amine-free) adhesive luting composite	UDMA and furthermethacrylate monomers. Inorganic fillers: ytterbium trifluoride and spheroid mixed oxide. Particle size: 0.04-0.2µm (mean:0.1 µm). Volume of inorganic fillers:38%, 60-68 wt%. Ivocerin for initiator. Additional ingredients: Stabilizers and pigments.
RelyX U200	3M ESPE	Self-adhesive dual-cure (methacrylated aliphatic amine) composite cement	Bis-GMA, TEGDMA, methacrylate monomers containing phosphoric acid groups, stabilizer components rheologic additives, alkaline (basic) initiator components, pigments. Inorganic silanated fillers: 43 V%, 72 wt% Sodium p-toluensulfinate, cam-phorquinone for initiator.
Panavia F2.0	Kuraray Noritake	Dual-Cure Adhesive Resin cement	Silanated barium glass, silanated silica, surface-treated sodium fluoride, bis-phenol poly ethoxy dimethacrylate, MDP, Hydrophobic dimethacrylate, Hydrophilic dimethacrylate, benzoyl peroxide, sodium aromatic sulfinate, N, N-diethanol p-toludine, photo-initiator

UDMA= urethane dimethacrylate; Bis-GMA= bisphenol A glycol dimethacrylate; TEGDMA= triethylene glycol dimethacrylate; MDP= Methacrylol oxidecyl dihydrogen phosphate

*Information supplied by the manufacturers

Table 2. Shear Bond Strength Values According to Materials and Solution Type

Material	Solution	Shear Bond Strength
Panavia	Distilled water	26.57± 10.21 MPa[a]
Relyx U200	Distilled water	25.96 ± 8.08 MPa[a]
Vario. Link	Distilled water	18.79±4.48 MPa[b]

Different superscript letters(lowercase for vertical lines) indicate significant differences ($p<0.05$).

References

1. Ahrari F, Heravi F, Rashed R, Zarrabi MJ, Setayesh Y. Which factors affect dental esthetics and smile attractiveness in orthodontically treated patients? J Dent (Tehran, Iran). 2015;12(7):491.
2. Yavuz Ö, Toksavul S, User A. Tüm seramik kronların kırılma dayanıklılıklarının seramometal restorasyonlarla karşılaştırılması. Ege Üniv Diş Hek Fak Derg. 1999;20:102-110.
3. Potiket N, Chiche G, Finger IM. In vitro fracture strength of teeth restored with different all-ceramic crown systems. J Prosthet Dent. 2004;92(5):491-495.
4. Beall AE. Can a new smile make you look more intelligent and successful? Dent Clin North Am. 2007;51(2):289-297.
5. Bailey SJ, Swift Jr EJ. Effects of home bleaching products on composite resins. Quintessence Int. 1992;23(7).
6. Calamia JR, Calamia CS. Porcelain laminate veneers: reasons for 25 years of success. Dent Clin North Am. 2007;51(2):399-417.
7. Magalhães APR, Cardoso PdC, de Souza JB, Fonseca RB, Pires-de-Souza FdCP, Lopez LG. Influence of activation mode of resin cement on the shade of porcelain veneers. J Prosthodont. 2014;23(4):291-295.
8. Abo-Hamar SE, Hiller K-A, Jung H, Federlin M, Friedl K-H, Schmalz G. Bond strength of a new universal self-adhesive resin luting cement to dentin and enamel. Clin Oral Investig. 2005;9(3):161-167.
9. Hikita K, Van Meerbeek B, De Munck J, Ikeda T, Van Landuyt K, Maida T, et al. Bonding effectiveness of adhesive luting agents to enamel and dentin. Dent Mater. 2007;23(1):71-80.
10. Liao T, Li K, Breder K. Flexural strength of ceramics ground under widely different conditions. J Mater Process Technol. 1997;70(1-3):198-206.
11. Otani A, Amaral M, May LG, Cesar PF, Valandro LF. A critical evaluation of bond strength tests for the assessment of bonding to Y-TZP. Dent Mater. 2015;31(6):648-656.

12. Scherrer SS, Cesar PF, Swain MV. Direct comparison of the bond strength results of the different test methods: a critical literature review. Dent Mater. 2010;26(2):e78-e93.

13. Toman M, Toksavul S, Akin A. Bond strength of all-ceramics to tooth structure: using new luting systems. J Adhes Dent. 2008;10(5):373-378.

14. Naranjo J, Ali M, Belles D. Comparison of shear bond strength of self-etch and self-adhesive cements bonded to lithium disilicate, enamel and dentin. Tex Dent J. 2015;132(11):914-921.

15. Guarda GB, Gonçalves LS, Correr AB, Moraes RR, Sinhoreti MA, Correr-Sobrinho L. Luting glass ceramic restorations using a self-adhesive resin cement under different dentin conditions. J Appl Oral Sci. 2010;18:244-248.

16. Kim J-H, Chae S, Lee Y, Han G-J, Cho B-H. Comparison of shear test methods for evaluating the bond strength of resin cement to zirconia ceramic. Acta Odontol Scand. 2014;72(8):745-752.

17. St-Georges AJ, Sturdevant JR, Swift Jr EJ, Thompson JY. Fracture resistance of prepared teeth restored with bonded inlay restorations. J Prosthet Dent. 2003;89(6):551-557.

18. Scheibenbogen A, Manhart J, Kunzelmann K-H, Hickel R. One-year clinical evaluation of composite and ceramic inlays in posterior teeth. J Prosthet Dent. 1998;80(4):410-416.

19. Conrad HJ, Seong W-J, Pesun IJ. Current ceramic materials and systems with clinical recommendations: a systematic review. J Prosthet Dent. 2007;98(5):389-404.

20. Scientific Documentation Monobond Plus, Ivoclar Vivadent AG Research & Development, March 2009; https://www.ivoclarvivadent.com/zoolu-website/media/document/1001/Monobond+Plus.

21. Scientific Documentation SpeedCEM Plus, Ivoclar Vivadent AG Research & Development, May 2016; https://www.ivoclarvivadent.com/zoolu-website/media/document/36822/SpeedCEM+Plus.

22. Elsayed A, Younes F, Lehmann F, Kern M. Tensile bond strength of so-called universal primers and universal multimode adhesives to zirconia and lithium disilicate ceramics. J Adhes Dent. 2017;19(3):221-228.

23. Tanış MÇ, Akay C, Akçaboy TC, Şen M, Kavaklı PA, Sapmaz K. In vitro shear bond strength between fluorinated zirconia ceramic and resin cements. J Adv Prosthodont. 2018;10(3):205-210.

24. Yang L, Chen B, Xie H, Chen Y, Chen Y, Chen C. Durability of resin bonding to zirconia using products containing 10-methacryloyloxydecyl dihydrogen phosphate. J Adhes Dent. 2018;20(4):279-287.

25. Cho J, Chen Y, Min B, Kim H, Kwon O, Shon K, et al. Effects of essential oils supplementation on growth performance, IgG concentration and fecal noxious gas concentration of weaned pigs. Asian-Australas J Anim Sci. 2005;19(1):80-5.

26. Subaşı MG, İnan Ö. Influence of surface treatments and resin cement selection on bonding to zirconia. Lasers Med Sci. 2014;29(1):19-27.

27. Reis A, Grandi V, Carlotto L, Bortoli G, Patzlaff R, Accorinte MdLR, et al. Effect of smear layer thickness and acidity of self-etching solutions on early and long-term bond strength to dentin. J Dent. 2005;33(7):549-559.

28. Tay FR, Pashley DH. Have dentin adhesives become too hydrophilic? J Can Dent Assoc. 2003;69(11):726-732.

29. Zhang C, Degrange M. Shear bond strengths of self-adhesive luting resins fixing dentine to different restorative materials. J Biomater Sci Polym Ed. 2010;21(5):593-608.

30. Gundogdu M, Aladag L. Effect of adhesive resin cements on bond strength of ceramic core materials to dentin. Niger J Clin Pract. 2018;21(3):367-.

31. Sokolowski G, Szczesio A, Bociong K, Kaluzinska K, Lapinska B, Sokolowski J, et al. Dental Resin Cements—The Influence of Water Sorption on Contraction Stress Changes and Hydroscopic Expansion. Mater. 2018;11(6):973.

32. Pekkan G, Hekimoglu C. Evaluation of shear and tensile bond strength between dentin and ceramics using dual-polymerizing resin cements. J Prosthet Dent . 2009;102(4):242-252.

33. Strub JR, Beschnidt SM. Fracture strength of 5 different all-ceramic crown systems. Int J Prosthodont. 1998;11(6).