ATATÜRK ÜNİVERSİTESİ YAYINLARI
ATATURK UNIVERSITY PUBLICATIONS

Current Research in Dental Sciences

Research Article *Araştırma Makalesi* DOI: 10.5152/CRDS.2024.22118

Evaluation of the Effect of Dental Technicians' Ceramic Application Experience on Metal–Ceramic Bonding: A Pilot Study

Diş Teknisyenlerinin Seramik Uygulama Deneyiminin Metal Seramik Bağlanmasına Etkisinin Değerlendirilmesi: Bir Pilot Çalışma

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ABSTRACT

Objective: The aim of this study was to evaluate the effect of dental technicians' experience on the shear bond strength (SBS) of ceramic fused to metal restorations.

Methods: Totally 32 casting cobalt–chromium (Co-Cr) disc-shaped (r = 10 mm diameter, h = 1 mm height) specimens were prepared for 2 experimental groups [group 1: untrained dental technician, group 2: conversant dental technician] (n = 16 per group). Ceramic was applied to the disc specimens (h = 4 mm height, r = 6 mm diameter), and their SBS was measured with a universal testing device. Results were statistically analyzed using the Student's t-test (α = .05).

Results: According to the Student's t-test, no statistically significant differences were seen between the 2 groups (P = .270).

Conclusion: The experience of the dental technicians did not affect the bond strength of casting Cr-Co alloys.

Keywords: Experience, technician, metal–ceramic bonding

ÖZ

Amaç: Bu çalışmanın amacı teknisyen deneyiminin metal destekli seramik restorasyonların makaslama bağlanma direncine (shear bond strength-SBS) etkisinin olup olmadığının araştırılmasıdır.

Yöntemler: 32 tane döküm Co-Cr disk (10 mm çapında, 1mm kalınlığında) şeklinde örnek iki ayrı çalışma grubu [Grup 1: Deneyimsiz diş teknisyeni (Untrained dental technician-UDT), Grup 2: Deneyimli diş teknisyeni (Conversant dental technician-CDT)] (n = 16 her bir grup için) hazırlandı. Örneklere seramik uygulaması (4 mm yüksekliğinde, 6 mm çapında) yapıldı ve SBS üniversal bir test cihazı ile ölçüldü. Sonuçlar istatistiksel olarak Student t-test ile analiz edildi (α = .05). Bulgular: Deney grupları arasında istatistiksel olarak anlamlı bir sonuç bulunmamıştır (P = .270).

Sonuç: Diş teknisyeninin deneyimli olup olmamasının döküm Co-Cr alaşımlarının bağlanma direncine etkisi görülmemiştir.

Anahtar kelimeler: Deneyim, teknisyen, metal-seramik bağlanması

INTRODUCTION

Nowadays, the fixed prosthetic dentures (FPD) have a variety of material options for different indications. Ceramics fused to different substructure metals, zirconia, full ceramics, and monolithic zirconia blocks are used for fixed prosthetic restorations.[1,2] Although all-ceramic crowns are gaining popularity, approximately 80% of FPD are ceramic-fused-to-metal restorations.[1,3] The most important preference factor of the metal–ceramic restorations is long-term clinical success, and this factor is influenced by case selection, tooth preparation, impression, lab facilities, cementation, and practitioner age.[4,5]

Received/Geliş Tarihi: 28.10.2022
Accepted/Kabul Tarihi: 17.12.2022
Publication Date/Yayın Tarihi: 18.01.2024

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Cite this article as: Baysal N, Erol BF. Evaluation of the Effect of Dental Technicians' Ceramic Application Experience onto the Metal–Ceramic Bonding: A Pilot Study. *Curr Res Dent Sci.* 2024;34(1):35-39.

The amount of support that the metal framework will provide to the ceramic is directly proportional to the quality of the metal–ceramic bond.[3] The bonding of porcelain to metal alloy is vital for the success of ceramic-fused-to-metal restorations, especially under the rigors of oral function.[2] Despite the advantages of metal–ceramic crowns/bridges, the bonding problems between metal and ceramic cause very high rates of failure.[2,6] These failures occur due to the incompatibility of the coefficient of thermal expansion between the metal and veneer ceramics, the surface properties of metal frameworks (surface roughness, wetting capability), improperly designed frameworks, inappropriate firing conditions, and other factors.[2,4,6-8] Therefore, quite a lot of research has been done to make this bonding stronger.

The application of ceramic to the metal frameworks includes a series of technical procedures according to the manufacturing instructions. To mask the base metal color, first opaque ceramic is applied to the framework and then the dentin ceramic is applied by the technicians.[9,10] These steps are applied by using brushes. Therefore, the thickness of the opaque and dentin layers and the aesthetics results of the restorations depend on the technicians' expertise and skill in his area.[9-11] Dental technicians put a great deal of effort into designing and manufacturing prosthetic restorations. Although the share of technicians in scientific studies is ignored, it is advocated to take this into consideration.[9-11] It is very important to inform the technician about the biological and clinical factors to be considered in the design and production of the prosthesis, and this communication has a great impact on the success of the prosthesis.[12] Another important factor is the skill of the technician.[9] Today, many studies have been carried out on the properties of the materials used and the evaluation of the effect of production methods on the success of prostheses.[13-15] However, there are limited studies on the evaluation of parameters related to technicians, who have the largest share in the production of prosthesis.

The aim of the present study was to evaluate the effect of dental technicians, who are untrained and conversant, on the bonding values between the ceramic and casting cobalt–chromium (Co-Cr) alloy. The null hypothesis was that the bond strength of the specimens produced by the conversant dental technicians would be higher than the untrained group.

MATERIAL AND METHODS

In total, 32 casting Co-Cr alloy disc (r = 10 mm diameter, h = 1 mm height) specimens were prepared for 2 experimental groups [group 1: untrained dental technician (UDT), group 2: conversant dental technician (CDT)] (n = 16) to analyze the shear bond strength (SBS).

Casting disc specimens were produced with a specially designed aluminum mold to reach a standard dimension. To obtain the negative spaces of this mold for preparing wax patterns (Kronenwachs; Bego, Bremen, Germany) a liquid silicone (Platsil73-29; Polytek Development Corp) was used.[4] These wax patterns were invested with phosphate-bonded investment material (Bellavest SH, Bego, Bremen, Germany). Following wax elimination, 32 specimens were cast from Co-Cr alloy (Remanium® star, CL, Dentaurum, Ispringen, Germany) according to the manufacturers' instructions by an induction-casting machine (Fornax, Bego, Breman, Germany). The castings were divested, and the casting defects were removed with a low-speed hand piece (10 000 rpm) by using a laboratory tungsten bur. Following this, the specimens were airborne-particle abraded with 110-µm Al_2O_3 particles (Korax, Bego, Bremen, Germany), at a pressure of 0.5 MPa applied for 10 seconds at a distance of 2 cm. Then the specimens were ultrasonically (Biosonic JR, Whaledent Int. NY, USA) cleaned in distilled water.

Before the feldspathic ceramic application, the casting specimens were divided into 2 groups (n = 16) and distributed to the technicians. One of the dental technicians (CDT) was senior in his work and had been studying in this area for about 12 years. The other technician had just graduated from the technician school and was inexperienced in his work. Two of the technicians were informed about how to use the specified molds for ceramic application. Then the feldspathic ceramic was applied to the disc specimens by the technicians according to the manufacturer's instructions. During the ceramic application process, the technicians were free to choose the time that they needed to apply the ceramic to the specimens. First, a layer of opaque ceramic (Ceramco3 Base Pasta, Dentsply, USA) was applied, and then the second layer of opaque (Ceramco3 Pasta Opaque, Dentsply, USA) was applied on the first layer of opaque. Subsequently, dentin ceramic (Ceramco3 Dentin, Dentsply, USA) was applied by using liquid silicone molds[4] (4 mm height and 6 mm diameter), and firing was performed in a porcelain furnace (Programat P300 Ivoclar Vivadent AG, Liechtenstein). The feldspathic ceramic firing temperature procedures are seen in Table 1.

After ceramic application was completed, the specimens were subjected to the aging procedure. This procedure consisted of 5500 cycles of alternate water-bath immersion at 4°C and 60°C at a dwell time of 1 minute each temperature.

The specimens were embedded in auto-polymerized acrylic resin (Simplex Rapid Powder, Kemdent, Swindon) using silicone molds (12 x 12 x 12 mm^3). Shear force was applied to the metal–ceramic interface in a universal testing machine (Lloyd Instruments LRX) with a shearing blade at a crosshead speed of 1 mm/min until failure occurred. Peak force values at failure were recorded in Newton (N) and divided by the surface area to obtain the bond strength values (MPa = N/mm^2).

After the SBS test, the debonding surfaces of the 2 specimen groups were examined by 2 operators to determine the failure modes. Specimens were then grouped into 3 categories: adhesive (no ceramic left on the alloy surface), cohesive (no alloy

Table 1. The Feldspathic Ceramic Fiiring Temperature Chart

°C	Time (minutes)			Time (minutes)		Vacuum	Set Temperature		Temperature		
Program Description	Dry	Preheat	Vacuum	Hold	Cool	Set Point (in Hg)	Idle	High Temperature	Vacuum Start	Vacuum Stop	Heat Rate °C/min
1. Pasta opaque	3	3	0	0	0	29	500	975	500	975	100
2. Powder opaque	5	3	0	0	0	29	650	970	650	970	70
1. Dentin	5	5	0	0	0	29	650	950	650	950	55
2. Dentin	5	5	0	0	0	29	650	950	650	950	55

surface, failure occurred just within the opaque ceramic), and mixed (partially ceramic left on the alloy surface) failure.

Statistical analysis was performed using Statistical Package for the Social Sciences Statistics version 25.0 software program (IBM Corp.; Armonk, NY, USA). The results of the SBS were statistically analyzed with a Student *t*-test after examining the data by the Shapiro–Wilk test for normality ($\alpha = .05$).

RESULTS

The descriptive statistics for the SBS are presented in Table 2. The results of the Student *t*-test comparing the 2 experimental groups ($t = -1.132$) indicated that there were no statistically significant difference between the groups ($P = .270$). The mean SBS of the UDT group was 17.72 ± 2.61 MPa and that of the CDT group was 19.37 ± 5.244 MPa. The distribution of failure types of the experimental groups is shown in Figure 1.

DISCUSSION

The aim of the present study was to evaluate the effect of dental technicians, who are untrained and conversant, on the bonding values between the ceramic and casting Cr-Co alloy. The null hypothesis that the bond strength of the specimens produced by the conversant dental technicians would be higher than that of the untrained group was rejected. There was no statistically significant difference in SBS between the untrained and conversant dental technician groups.

To improve the long-term success of the FPD, the researchers evaluated the manufacturing methods, variety of ceramic materials, different surface treatments, different firing conditions, etc.[1,13,15-17] However, there is limited research on the effect of experience of the dental technician on the metal–ceramic bond of the FPD, as the application of the ceramic to the metal framework mostly depends on the manipulation skill of the dental technician. Pişkin et al[9] investigated the effect of different dental technicians on the thickness of the opaque layer and color of the ceramic. They reported that the opaque layer thickness and the color of the ceramic had been significantly effected from different dental technicians.[9] In the present study, all steps of the specimens' preparation were performed by another conversant technician up to the ceramic application stage to reach a standard. Then the ceramic was applied to the specimens by the untrained and conversant dental technicians. The ceramic was applied to the specimens by these technicians in 4 steps; 2 opaque layers and 2 dentin layers. In the present study, as mentioned in the null hypothesis, SBS values of the CDT group were expected to be higher than the UDT group. However, although the mean SBS value (19.37 ± 5.24 MPa) of the CDT group was higher than the UDT (17.72 ± 2.61 MPa) group, statistically no significant differences were found between the groups. DDuring the ceramic application period no time limit was imposed to technicians. Therefore it is considering that the UDT group technician was able to take sufficient care in his specimens' preparation steps. When we evaluate the box plot (Figure 2), the SBS values for the UDT group demonstrate more normal distribution than the CTD group. The range between the minimum and maximum SBS values of the UDT group was smaller than the CTD group. This situation may be the result of that the conversant technician may be work more imprecisely on specimens than untrained technician due to relying on his laboratory experience.

The adhesion strength between metal and ceramic can be tested with different testing methods such as shear strength test, biaxial flexural test, 3-point bending test, and 4-point bending test.[13,16] Three-point bending test is the grade of International Organization for Standardization (9693) standard; however, the SBS test is used in this study due to the easy preparation of the specimens. In the present study, SBS test specimen design was prepared as in the previous studies,[4,13,18] and the specimen size was determined to tolerate the nonhomogeneous stress distribution of the SBS test.

Values of SBS in the 2 study groups were lower than 25 MPa in this study. This value is the accepted bond strength value between metal and ceramic by the International Standard (ISO9693).[1,15,17,18] The lower values of bond strength may be explained by the

Table 2. Descriptive Statistics (in MPa) and Results of the Student *t*-test Comparisons of the Shear Bond Strength of Metal–Ceramic Bond Between the Untrained Dental Technician and Conversant Dental Technician

Group Tested	n	Mean (MPa)	SD	Range
UDT	16	17.72	2.61	13.74-22.05
CDT	16	19.37	5.24	12.02-27.72

t-test = −1.132; $P = .270$.
CDT, conversant dental technician; MPa, megapascal; UDT, untrained dental technician.

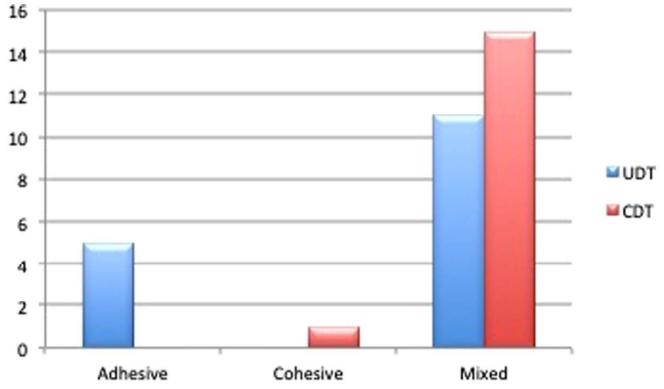

Figure 1. Distribution of failure modes for experimental groups analyzed after shear bond strength test test. UDT, untrained dental technician; CDT, conversant dental technician.

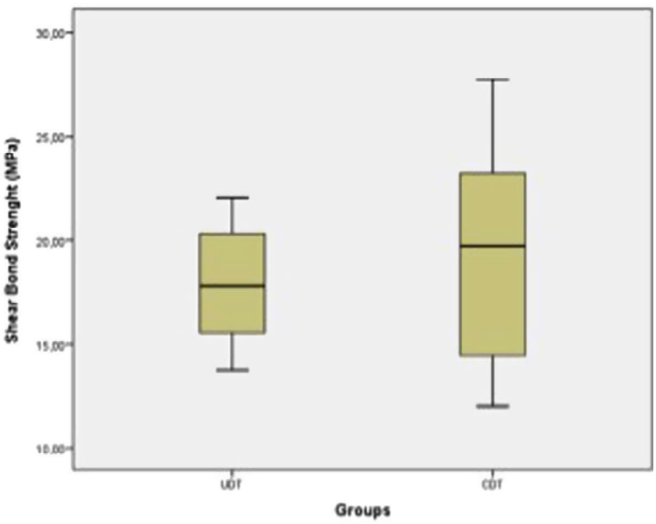

Figure 2. Shear bond strength of untrained dental technician and conversant dental technician experimental groups.

application of aging process. As mentioned in the previous studies, the aging processes cause a decrease in metal–ceramic bonding.[17,18,19] Trindade et al[20] reported that the temperature changes during aging procedure cause stress between metal and ceramic due to the different coefficient of thermal expansion values of the materials, and this situation weakens the SBS of the specimens.

In the present study, there were seen 5 adhesive failures in the UDT specimen group, whereas there were none in the CDT group. Additionally, nearly both of the other failure types of the 2 groups were mixed failures. During the ceramic application processes, the application of the opaque layer depends on the brush skill of the dental technician.[9,10] The large number of adhesive failures of the UDT group may be due to the brushing skills of the untrained technician. As a limitation of this study, the opaque layer thicknesses of the specimen groups were not measured before the dentin application process. Xu et al[21] had reported that opaque layer thicknesses have an influence on the bond strength of metal–ceramic restorations. Therefore, the UDT technician's opaque layer application may have been weaker than the CDT technician's opaque layer application. This may be the cause of the large number of adhesive failures that were seen in the UDT group.

Based on the results of the present study, as dental technician experience did not affect the metal–ceramic bonding, the dental laboratories may work with the newly graduated dental technicians. However, time limitations and morphology of the restorations should be taken into account, as these are skills that can be developed over time. Another limitation of this study is the number of technicians. Working with more technicians would demonstrate a more general result.

The results of this in vitro study reached the following conclusions. The experience of the technicians was not affected by the bond strength of casting Co-Cr alloys. The dental laboratories can give a chance to untrained technicians for restoring metal ceramic restorations without time limits.

Ethics Committee Approval: As it was an in-vitro study, the ethics committee approval was not considered necessary.

Informed Consent: As it was an in-vitro study, informed consent was not obtained.

Peer-review: Externally peer-reviewed.

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

Acknowledgements: The authors thank Dr. Ruhi Kulez for his laboratory support and newly graduated dental technician Ferhat Çelik for his contributions to specimen preparation. Additionally, since this was an in-vitro study and did not include any patients, the ethics committee approval application was not seen as necessary.

Declaration of Interests: The authors declare that they have no competing interest.

Funding: The authors declared that this study has received no financial support.

Etik Komite Onayı: Bu çalışma in vitro bir çalışma olduğu için etik kurul onayı gerekli görülmemiştir.

Hasta Onamı: Bu çalışma in vitro bir çalışma olduğu için hasta onamı alınmamıştır.

Hakem Değerlendirmesi: Dış bağımsız.

Yazar Katkıları: Fikir– N.B., B.F.E.; Tasarım – N.B., B.F.E.; Denetleme – N.B., B.F.E.; Kaynaklar – N.B., B.F.E.; Malzemeler – N.B., B.F.E.; Veri Toplanması ve/veya İşlemesi – N.B., B.F.E.; Analiz ve/veya Yorum – N.B., B.F.E.; Literatür Taraması – N.B., B.F.E.; Yazıyı Yazan – N.B., B.F.E.; Eleştirel İnceleme – N.B.

Teşekkür: Yazarlar olarak laboratuar desteğinden dolayı sayın Dr. Ruhi Kulez'e ve numune hazırlamadaki katkılarından dolayı yeni mezun diş teknisyeni sevgili Ferhar Çelik'e teşekkür ederiz.

Çıkar Çatışması: Yazarlar çıkar çatışması bildirmemişlerdir.

Finansal Destek: Yazarlar bu çalışma için finansal destek almadıklarını beyan etmişlerdir.

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