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Effect of Different Repair Techniques on Shear Bond Strength of Dental Ceramics

Dental Seramiklerin Tamirinde Kullanılan Farklı Yöntemlerin Makaslama Kuvvetlerine Etkisi

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ABSTRACT Objective: Dental ceramics have superior characteristics for fixed restorations. However, crack propagation and chipping are also common problems. Repair availability of a restoration would be advantagous for both clinician and patient.The aim of this study was to compare different repair techniques and materials. **Material and Methods:** Fifty specimens were fabricated from feldspathic ceramic. The specimens were divided into 5 groups (n=10) for different repair techniques. For the direct repair, a repair set was used and composite resin was applied using a silicone matrix. For indirect repair, the composite resin and ceramic repair components were prepared. All ceramic surfaces were etched with 40% phosphoric acid. For cementation of the repair ceramic and repair composite resin, a dual polymerized composite resin or a commercial cyanoacrylate (CA) was used. After cementation/CA application, all specimes were thermocycled. The shear test was performed with 5-mm/min crosshead speed. The shear bond strength values were recorded in Newton and converted into megapascal (MPa). Data (MPa) were analyzed using Kruskal-Wallis non-parametric test, and for the multiple comparisons, the Dunn test was used with Benforrini corrections (α=.05). **Results:** The higher mean shear bond strength values were observed with the direct composite resin repair technique (20.73MPa), composite resin applied with CA (14.77 MPa), and ceramic cemented with dual-polymerized composite resin (14.98 MPa), The lowest shear bond strength value was observed with the ceramic-to-ceramic bonding with CA (8.59 MPa). **Conclusion:** Direct repair technique showed the best shear bond strength values while other techniques can be used for interim solutions.

Keywords: Fixed partial denture; dental ceramics; repair; shear bond strength; cyanoacrylate

ÖZET Amaç: Dental seramikler sabit restorasyonlar için üstün özelliklere sahiptir. Ancak çatlak oluşumu ve kırıklar genel problemlerdendir. Restorasyonun tamir edilebilir olması hem klinisyen hem de hasta için avantajlı olacaktır. Bu çalışmanın amacı farklı tamir yöntemleri ve materyallerini karşılaştırmaktır. **Gereç ve Yöntemler:** Feldspatic seramikten elli örnek hazırlanmıştır. Örnekler tamir yöntemlerine göre 5 gruba (n=10) ayrıldı. Direkt tamir yöntemi için tamir seti kullanılarak silikon matrix ile kompozit rezin uygulanmıştır. İndirekt tamir yöntemi için kompozit rezin ve seramik parçalar hazırlanmıştır. Tüm seramik yüzeylere %40 fosforik asit uygulanmıştır. Tamir seramiğini ve tamir kompozit rezini, dual polimerize kompozit rezin veya ticari siyanoakrilat (CA) ile siamnte edilmiş/yapıştırılmıştır. Tüm örneklere termosiklus uygulanmıştır. Makaslama testleri 5-mm/dak. hızda yapılmıştır. Makaslama kuvvetleri Newton cinsinden ölçülmüş daha sonra megapaskal (MPa) cinsine çevrilmiştir. İstatistiksel analizler (MPa) Kruskal-Wallis non-parametrik testi ile değerlendirilmiş, karşılaştırmalar Benforrini düzeltmeleriyle Dunn testi kullanılarak yapılmıştır (α=,05). **Bulgular:** En yüksek makaslama kuvvetleri direkt kompozit rezin ile tamir tekniğinde gözlenmiştir (20,73MPa). Daha sonra sırasıyla CA ile yapıştırılmış kompozit rezin (14,77 MPa) ve dual-polimerize kompozit rezin ile simante edilen örneklerde gözlenmiştir (14,98 MPa). En düşük değerler seramik tamir parçalarının CA ile seramiğe yapıştırıldığı grupta gözlenmiştir (8,59 MPa). **Sonuç:** Direkt tamir tekniği en iyi makaslama bağlantı kuvveti değerlerini gösterirken diğer yöntemler ara çözüm olarak değerlendirilebilir.

Anahtar Kelimeler: Sabit kısmi protez; dental seramikler; tamir; makaslama kuvveti, siyanoakrilat

Dental ceramics have been the first choice for fixed restorations due to their superior characteristics such as color stability, natural appereance, biocompability and low thermal conductivity.[1,2] Besides their advantages, ceramics are prone to crack propagation and chipping.[1,2]

There are many techniques reported in the literature for direct or indirect ceramic repair.[1-3] Although generally successful, indirect techniques require time-consuming laboratory procedures. Direct repair technique with composite resin is an alternative with advantages, because their application is relatively easier saving time to the clinician and the patient.[2,3] However, achieving a durable and reliable bond between ceramic and composite resin may be difficult.[2,4]

The bonding of ceramic and composite resin can be achieved using two mechanisms; micro-mechanical and chemical. Micro-mechanical bond can be achieved by etching and/or abrading the ceramic surface, and chemical bonding can be achieved using silane coupling agents.[1,3,4]

Cyanoacrylate (CA) adhesives were introduced in 1949 and now is used in industry and at home to bond anything to anything till decades.[5,6] Besides, CA also has applications in medicine and dentistry with an additional advantage of its bacteriostatic characteristics.[6] CA has a wide range of dental applications as a tissue adhesive, fissure sealent, and dentin desensitizer.[6-8] However studies about using CA as repair material are limited.

CA consists of a compound of cyanoacetate with formaldehyde.[5,6] The rapid polymerization of CA is triggered by hydroxil groups on the surface of the material. The adhesive quality of the CA in the moist enviroments is superior when compared with other adhesives both medical and industrial.[6] Short polymerization time is also an advantage. The clinical and histological studies report favorable results while no toxicokinetic information is available for CA.[6]

Considering the problems related with fracture of ceramics and different repair techniques, this study aimed to evaluate the bond strength of indirect repair technique of cementing ceramic or composite resin with a commercially available CA. The null hypothesis was that using CA for ceramic repair would provide similar shear bond strength when compared with conventional systems.

MATERIAL AND METHODS

Fifty disk-shaped specimens were fabricated (10 mm in diameter and 2 mm thickness) from feldspathic ceramic (Vita VMK Master, Bad Sackingen, Germany) using a matrix (Table 1). The specimens were then placed in an oven and fired at 920°C according to the manufacturer's instructions. No glaze was applied on the ceramics and they were ground finished with 600 grid sandpaper. After finishing, the specimens were ultrasonically cleaned in distilled water.

Ceramic specimens were divided into 5 groups (n=10) for different repair techniques;

a) direct repair of ceramic with composite resin,

b) indirect repair of ceramic with composite resin cemented with dual-polymerized composite resin,

c) indirect repair of ceramic with composite resin bonded with CA,

d) indirect repair of ceramic with ceramic cemented with dual-polymerized composite resin,

e) indirect repair of ceramic with ceramic cemented with CA.

For direct repair (Group a), a repair set (Clearfil Repair Multi Purpose, Kuraray, Japan) was used according to manufacturer's instructions and composite resin (Paradigm Nanohybrid Universal Com-

TABLE 1: Materials used in the study.

Ceramic specimens/ceramic repair	Vita VMK Master, Bad Sackingen, Germany
Composite resin	Paradigm Nanohybrid Universal Composite, 3M ESPE, St. Paul, MN, USA
Dual-cure resin	Panavia F2.0, Kuraray, NY, USA
Cyanoacrylate	Pattex, Henkel Adhesives, Aachen, Germany
Repair Set	Repair Multi Purpose, Kuraray, Japan

posite, 3M ESPE, St. Paul, MN, USA) was applied using a silicone matrix on the prepared specimen. The matrix was 5 mm in diameter and 2 mm in height and was used to standardize the repair material's size.

For indirect repair (Group b and c), the composite resin was polymerized inside the matrix (5 mm in diameter and 2 mm in height) individually and air abraded (Easyblast, Bego, Bremen, Germany) before cementation.

Ceramic repair materials (Group d and e) were fabricated using a method similar to the specimen fabrication.

All ceramic surfaces were etched with 40% phosphoric acid (K-Etchant gel, Kuraray, NY, USA) for 5 seconds and rinsed with water. For cementation of the repair ceramic and repair composite resin, a dual polymerized composite resin (Panavia F2.0, Kuraray, NY, USA) or a commercial CA (Pattex, Henkel Adhesives, Aachen, Germany) was used according to manufacturers'instructions.

After cementation/CA application, all specimes were thermocycled between 5°C and 55°C for 5000 times with a dwell time of 30 seconds. The shear test was performed with 5-mm/min crosshead speed and 500N load cell (Esetron, Ankara, Turkey). The shear bond strength values were recorded in Newton and converted into MPa with the formula "σ=F/S" where σ= shear bond strength, F= the load (N) at failure, S= surface area.

A software (SPSS 20.0) was used for statistical analysis. Data (MPa) were analyzed using Kruskal-Wallis non-parametric test, and for the multiple comparisons, the Dunn test was used with Benforrini corrections (α=.05).

RESULTS

A statistically significant difference was found for the shear bond strength (P<.001). The higher mean shear bond strength values were observed with the direct composite resin repair technique (20.73MPa), composite resin applied with CA (14.77 MPa), and ceramic cemented with dual-polymerized composite resin (14.98 MPa), and these values were statistically not different than each other (p>.05). The lowest shear bond strength value was observed with the ceramic-to-ceramic bonding with CA (8.59 MPa) (p<.05). Statistically significant differences amongst the groups were shown in (Table 2, Figure 1).

DISCUSSION

Ceramic fracture is a common problem and, it is still a common complication. To date, more durable or fracture-free ceramics are available, repair of the restorations is the easier and cheaper solution when compared with replacement of the restoration with a brand new one.[2,3,9]

In the literature, most of the studies focused on surface conditioning techniques of the ceramics however in this study two different repair materials and three methods of repair technique were evaluated.[1,3,9-11] The null hypothesis of this study was rejected because significant differences were found amongst groups. As surface conditioning of the ceramic specimens was standardized, the repair method and the material choice affected the outcomes.

TABLE 2: Shear bond strength values of specimens. Different superscript letters indicate significantly different groups.

Adhesive Material / Repair Material	n	Min	Max	Mean	Std. Deviation	Std. Error of Mean
Direct Composite	10	7.87	40.61	20.7330b	9.93777	3.14260
CA / Composite	10	4.27	35.00	14.7760bc	9.60404	3.03707
Dual Cure Resin / Composite	10	5.79	20.47	11.7200acd	4.39793	1.39075
CA / Ceramic	10	3.49	22.82	8.5980a	5.99430	1.89556
Dual Cure Resin / Ceramic	10	9.84	24.63	14.9870bd	4.40299	1.39235
TOTAL	50	3.49	40.61	14.1628	8.08435	1.14330

Std: Standart.

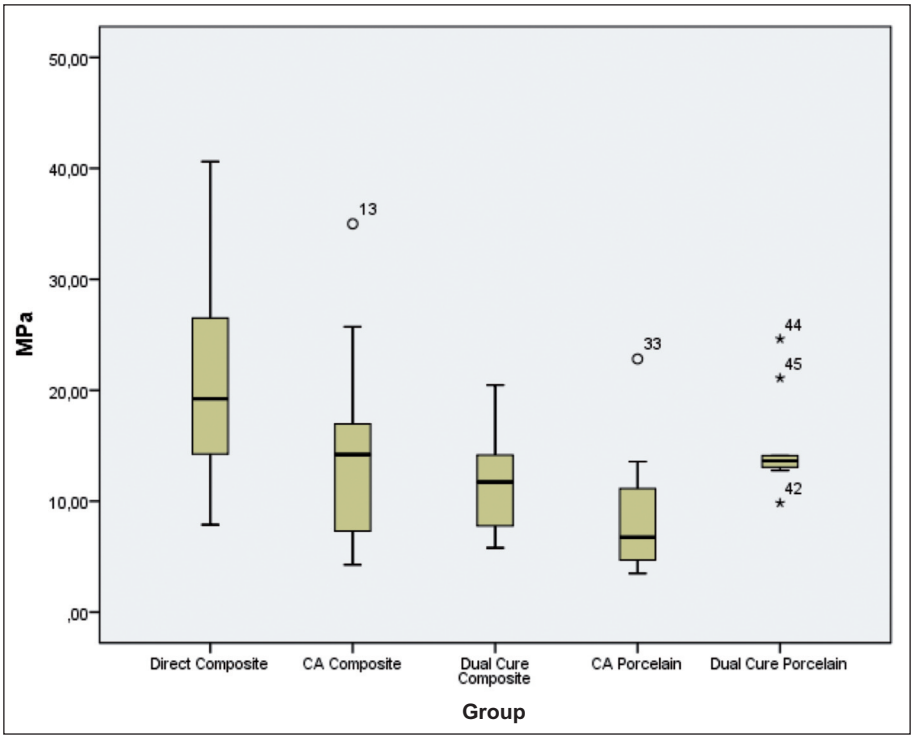

FIGURE 1: Mean shear bond strength values (MPa) and standard deviations.

Surface treatment of ceramic may be done with sandblasting, hydrofloric acid etching, and burs.[2,3,9] While sandblasting and using burs to create an irregular surface and are not technique sensitive, the success of acid etching depends on the type of the ceramic.[1,3] As surface treatment is essential for micromechanical adhesion, it has been reported that silicatization and silan application is necessary for chemical adhesion especially when working with ceramics with low silica content.[1,9] In the current study, acid etching was applied in order simulate the intra oral conditions.

There are studies in the literature with CA both in vitro and in vivo.[5,12] Although there are many commercially available CAs for hard and soft tissue repair, it was also reported in a study that CA may be cytotoxic and the exothermic polymerization may cause cell demage.[6] However, it was also reported in the same study that the cytotoxicity levels reduced considerably in 24 hours.[6-13] Repair with CA resulted in lower flexural strength than the conventional repair systems, however, CA application may be considered a quick interim solution. In current study, the composite resin was bonded to ceramic with CA and it was assumed that there would be no or minimal contact with the oral tissues and it would be a safe-to-use technique.

The rapid polymerization of CA can also be a disadvantage as 2 materials may not correctly align during the repair due to time constraints and the bond could be unsuccessful. It is also difficult to remove the CA from the surfaces.[5,6] Bottom line is that clinicians should act very rapidly to prevent indicated bonding complications. When the potential disadvantages of CA are considered as well as that the bond strength for composite resin when used directly and with CA is similar, it may be advantegous to use the composite resin directly rather than applying with CA. Although, one advantage of CA is that it does not cause any discoloration which may be because of the strong chemical bond to the glassy side.[5]

In the literature, it was reported that the mechanical and chemical adhesion should be a least 10 MPa.[1] Also, the bond strength of composite resin to enamel was reported to be 15-30 MPa.[9] However, it was also reported that the surface

treatments and silane application presented improved results; they did not exceed 30 MPa. It is an accepted situation that the bond strength of repairs cannot reach the bulk strength of the materials.[1,3] In current study, cementation of ceramic to ceramic with CA (Group e) did not show acceptable bond strength while the the other groups showed acceptable results which were over 10MPa. Bond strengths of CA and dual cure resin did not show statistically significant results, thus it is not possible to claim that one material was superior to other. However, conventional direct repair method showed the best results, and can be preferred.

In current study, the biocompability and cytotoxicity of commercial CA was not evaluated. Follow up studies should be conducted using CA for its safety during repair. Additionally, different CA types used for medical purposes can be evaluated for repair materials.

CONCLUSION

According to the results of the study direct repair of the ceramic restorations with composite resin would be more durable and reliable solutions. However, indirect repair of the ceramic restorations, especially when more aesthetic results were required, could be interim solutions until the restorations were changed.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea /Concept: *Serhat Emre Özkır, Server Mutluay Ünal;* ***Design:*** *Server Mutluay Ünal, Serhat Emre Özkır;* ***Control/Supervision:*** *Server Mutluay Ünal, Serhat Emre Özkır, Burak Yılmaz;* ***Data Collection and/or Processing:*** *Serhat Emre Özkır, Mehmet Biçer;* ***Analysis and/or Interpretation:*** *Serhat Emre Özkır, Server Mutluay Ünal, Burak Yılmaz;* ***Literature Review:*** *Serhat Emre Özkır, Mehmet Biçer;* ***Writing the Article****: Serhat Emre Özkır, Server Mutluay Ünal;* ***Critical Review:*** *Serhat Emre Özkır, Burak Yılmaz;* ***References and Fundings:*** *Serhat Emre Özkır;* ***Materials:*** *Serhat Emre Özkır, Server Mutluay Ünal.*

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