

Original research article

Influence of re-cementation on the retention of CAD/CAM zirconia copings over short titanium and zirconia abutments

Nurullah Türker , * Mehmet Mustafa Özarslan 

Department of Prosthodontics, Faculty of Dentistry,
Akdeniz University, Antalya, Turkey

ABSTRACT

OBJECTIVE: The aim of this study was to comparatively evaluate the effects of re-cementation on the retention of zirconia copings, which were cemented to short titanium and zirconia abutments with self-adhesive resin cement.

MATERIALS AND METHOD: Twelve titanium (Nucleoss T4 implants, NucleOSS T4 flat abutment, İzmir, Turkey) and 12 zirconia abutments (Zirkonzahn, Zirkonzahn GmbH, Bruneck, Italy) were used in this *in vitro* study. The titanium abutments were shortened to 3 mm and embedded in acrylic by fixing them with analogues. The zirconia abutments and copings were produced by scanning the abutments using the computer-aided design and manufacturing (CAD/CAM) method. All zirconia copings were cemented to the titanium and zirconia abutments with self-adhesive resin cement. Samples were subjected to a pull-out test in a universal testing device, and the bond strength values were recorded. Cement residues on the abutments and copings were removed with a handpiece that had a round head carbon steel bur, and an explorer. The copings were then re-cemented and retested using the pull-out test, and the strength values were recorded. Descriptive statistics were applied to the data, and the mean and standard deviation values were calculated. Bonferroni corrections with pairwise comparisons were used to compare the group and test effect at each level. $P < 0.01$ was considered as statistically significant.

RESULTS: The effect of the pre-test and end-test on bond strength ($p < 0.001$), the group effect on titanium and zirconia ($p < 0.001$) and the test-group interaction effect ($p < 0.001$) were all found to be statistically significant. A significant difference was observed between the titanium

and zirconia samples in terms of bond strength when the pre-test and end-tests were compared (titanium: $p < 0.05$, zirconia: $p < 0.001$). The end-test bond strength values were significantly lower than the pre-test bond strength values. Additionally, there was a significant difference between the titanium and zirconia samples in terms of bond strength change on comparison of the pre-test and the end-test. Decrease in bond strength values was higher in the zirconia samples ($p < 0.001$).

CONCLUSION: Re-cementation may adversely affect the bond strength of single-unit restorations on short abutments. In the case of re-cementation, a higher retention loss may occur in zirconia abutments than in titanium abutments.

KEYWORDS: Cementation; dental implant; titanium; zirconium

CITATION: Türker N, Özarslan MM. Influence of re-cementation on the retention of CAD/CAM zirconia copings over short titanium and zirconia abutments. *Acta Odontol Turc* 2020;37(3):78-83

EDITOR: Burcu Özdemir, Gazi University, Ankara, Turkey

COPYRIGHT: © 2020 Türker and Özarslan. This work is licensed under a [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/). Unrestricted use, distribution and reproduction in any medium is permitted provided the original author and source are credited.

FUNDING: None declared.

CONFLICT OF INTEREST: The authors declare no conflict of interest related to this study.

INTRODUCTION

There are several factors that enable the retention of a fixed implant-supported prosthetic restoration. Factors such as the design, shape, and size of the implant abutment; the surface roughness of the abutment and the intaglio surface of the crown; the existence of assisting grooves; and the type of adhesive cement all influence the retention of crowns.¹⁻⁴ The ideal retention can be achieved with a cementation process, which is carried out in consideration of all the above-mentioned factors.

Received: September 18, 2019; Accepted: May 13, 2020

*Corresponding author: Dr. Nurullah Türker, Akdeniz University, Faculty of Dentistry, Department of Prosthodontics, 07058, Antalya, Turkey;
E-mail: nurullahturker@hotmail.com

Crowns and bridges can be removed or de-cemented and re-cemented during routine clinical processes due to several factors, such as an examination of the supporting structures and tissues, the existence of additional procedures on restoration, or retention loss of the restoration. The re-cementation process is carried out after the current problem is solved and the abutment surface and inner surface of the restoration are cleaned. Other factors, such as surface smoothness and the amount of cement thickness (which affects the retention between the first and second cementation of the restoration), may change. The effect of re-cementation on bond strength has not been investigated sufficiently, and the few studies that discuss this topic have had contradictory results.⁵⁻⁷ More retention problems can be observed in single crown restorations on short abutments than in other restorations.⁸⁻¹⁰ Due to inadequate inter-arch space and aesthetic concerns, especially in anterior restorations, clinicians may use cemented type or short zirconia abutments. Titanium and zirconia materials have different mechanical surface properties, and the effects of re-cementation on the bond strength between the crowns and these materials are unknown. The aim of this study is to evaluate the effect of re-cementation on the retention of standard CAD/CAM zirconia copings, which are adhered to short titanium and zirconia abutments with a self-adhesive resin. The null hypothesis was as follows: re-cementation has no effect on the retention of standard CAD/CAM zirconia copings, which are adhered to short titanium and zirconia abutments with a self-adhesive resin.

MATERIALS AND METHOD

Twelve titanium abutment and 12 zirconia abutments were used in this *in vitro* study. Titanium abutments with a 1 mm gingival height were used for 3.8 and 4.2 mm diameter Nucleoss T4 implants (NucleOSS T4 flat abutment, İzmir, Turkey). The lengths of the titanium abutments were shortened to 3 mm with a metal guide ring; the zirconia abutments were produced from the titanium abutments, which were fixed with analogues with the CAD/CAM system. A 3-D computer model of the titanium abutments was created using an optic surface scanner (D700, 3shape A/S, Copenhagen, Denmark). Prefabricated Zirkozahn (Zirkozahn GmbH, Bruneck, Italy) blocks were used to produce the zirconia abutments. Partially sintered yttria-stabilized zirconia (Y-TZP) was used in the CAM unit. Following the milling procedure, the samples were sintered in the Zirkozahn sintering furnace (Zirkonofen 600, Zirkozahn Inc., Norcross, GA, USA) at 1500 °C for 8 hours according to the manufacturing company's procedure.

The implant analogues were placed vertically in a self-curing acrylic (Paladent, Heraeus Kulzer, Hanau, Germany) that was set in a cylindrical plastic pipe. A surveyor was used to control whether the analogues were vertical. The upper surface of the acrylic block was placed 1 mm above abutment-analogue connec-

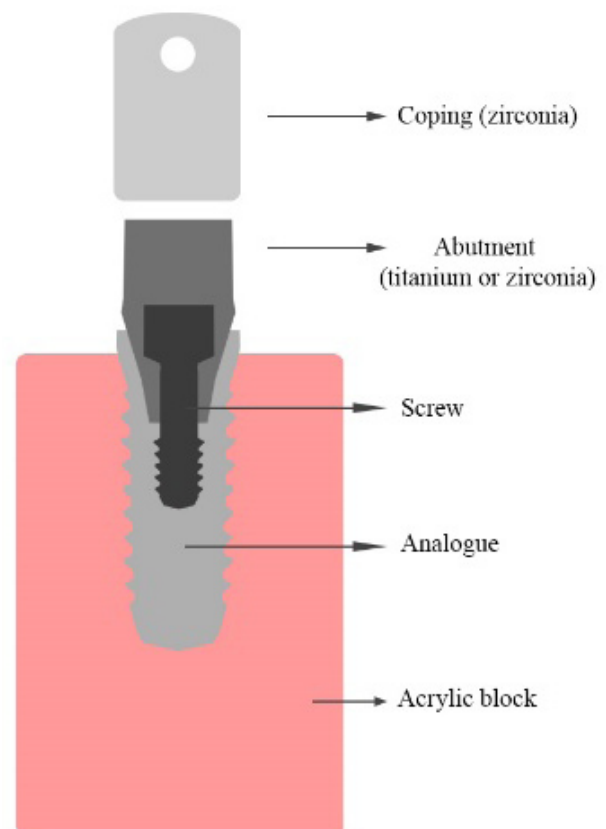


Figure 1. Representative drawing of the testing samples

tion. The plastic pipes were removed from the samples following the hardening process. All abutments were torqued with a torque strength of 25 N. The screw's entry points were closed with gutta-percha. The abutments were scanned with a 3-D scanning device (3Shape™, Copenhagen, Denmark), and an individual zirconia coping was produced for each abutment with a CAD/CAM device. The cement interval for all the samples was 25 µm. Each coping was produced with a hole in the top so that it could be connected to a universal testing device (Shimadzu, Model AG-50kNG, Shimadzu Co., Kyoto, Japan). The holes were drilled in a buccolingual direction from 2 mm below the top of each coping using 1.5 mm diameter drills. All the copings were cemented to abutments with self-adhesive resin cement (RelyX U200 Clicker 3M ESPE, St. Paul, MN, USA). The mixing and applying of the cement were carried out according to the manufacturing company's procedure. The dosing ratio of the two pastes was adjusted to 1:1 with the resin cement's special tube system. The two pastes were mixed with a cement spatula for 20 seconds on a mixing pad. The half-lengths of the copings were filled with cement, and an explorer tip was used to bring the cement into contact with the inner surface. Copings were placed on the abutments and finger pressure was applied for 2 minutes from the top of the copings. Residuary cement was cleaned with an explorer (Figure 1). The samples were then kept at 37 °C distilled water for 24 hours.

The samples were placed in the testing device. The acrylic part was pressed and fixed to the bottom section. A 0.7 mm steel wire was threaded through the holes in the zirconia copings, and the samples were tied to the upper part of the device (i.e., the puller). The copings were subjected to a pull-out test at a cross-head speed of 0.5 mm/minute in an abutment–analogue vertical axis direction (Figure 2). The pull strength was raised increasingly until the copings were detached from the abutments. The maximum bond strength levels that enabled the detachment of the copings from the abutments were recorded. This was the first test procedure.

The cement residues were removed with an explorer for a realistic simulation of a clinical situation. The inner parts of the copings were cleaned with a laboratory handpiece and a round steel bur. The abutments and copings were washed with dental unit water spray and dried with air. After the cementation phases were completed as previously explained, the copings were cemented to the abutments. The samples, which were kept in 37 °C distilled water for 24 hours, were subjected to a pull-out test, and the maximum strength levels were recorded. This was the second test procedure.

Descriptive statistics were applied to the data, and the mean and standard deviation values were taken. In this study, there were two groups and two test results. A repeated-measures mixed ANOVA test was applied to observe the change between the groups and

between the pre-test and end-tests.¹¹ The repeated-measures mixed ANOVA test had provided two main assumptions. First, the dependent variable should be approximately normally distributed for each level of the group. The second assumption was the homogeneity of variance for each combination of the groups. In the existing literature, there are different methods to test normality. These include, for example, the Shapiro–Wilk test, standardized skewness and kurtosis values, or a graphical review (Q–Q plots). In order to check the normal distribution, standardized kurtosis and skewness values were used.¹² The Levene's test results for the pre-test and end-test were $p=0.208$ and $p=0.842$, respectively. The Bonferroni correction with pairwise comparisons was used to compare the group and test effects on each level. Analyses were carried out by SPSS 23.0 (SPSS Inc., Chicago, IL, USA), and $p<0.05$ was accepted as statistically significant.

RESULTS

The effect of the pre-test and the end-test on bond strength ($p<0.001$), the group effect on the titanium and zirconia samples ($p<0.001$) and the test-group interaction effect ($p<0.001$) were all found to be statistically significant. A significant difference was observed between the titanium and zirconia samples in terms of bond strength when the pre-test and end-test were compared (titanium: $p<0.05$, zirconia: $p<0.001$). The decrease in retention values was higher in the zirconia samples (Table 1). There was a statistically significant difference in the titanium and zirconia samples in terms of bond strength change when the pre-test and end-test were compared. The decrease in bond strength values was higher in the zirconia samples ($p<0.001$). Though a significant difference was observed in the pre-test in terms of retention levels ($p<0.001$), there was no significant difference in the end-test ($p>0.05$; Table 1).

DISCUSSION

In this study, a significant decrease was observed after re-cementation with regard to the bond strength between zirconia coping and short abutments. The study's null hypothesis was rejected.

The main factors that provide effective retention may be adversely affected by the removal and re-cementation processes of restoration. Especially in single-unit restorations with short abutments, these processes may cause frequent de-cementation. Several studies have investigated and discussed the effects of re-cementation on retention with regard to restorations on natural teeth.^{6,7,13} Implant treatments have recently been widely used; these treatments have become routine procedures at dental clinics.^{14,15} Due to their aesthetic advantages, zirconia-supported restorations are now used more commonly than they were in the past.¹⁶ Additionally, there are no studies in the existing literature that have evaluated retention changes in the case

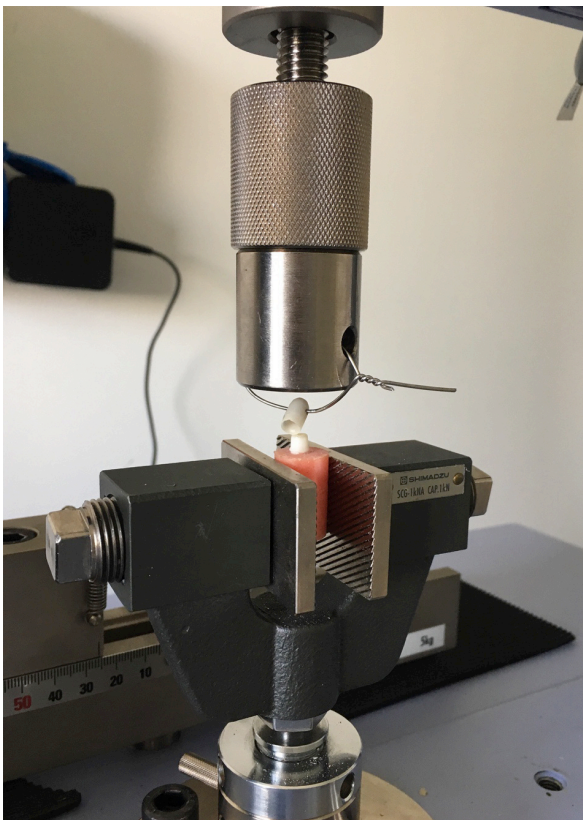


Figure 2. Pull-out test with a cross-head speed of 0.5 mm/min in the universal testing machine

Table 1. Mean, standard deviation (SD) values and changes in the bond strength values between the pre-test and end-tests

Group		Titanium (n=12)	Zirconia (n=12)	Total (n=24)	
Pre-test	Mean±SD	112.68±15.82	181.66±20.42	147.17±39.50	p < 0.0001
	Min-Max	100.41-155.94	157.01-222.05	100.41-222.05	
End-test	Mean±SD	92.25±17.15	94.57±15.02	93.41±15.81	p = 0.728
	Min-Max	77.08-130.33	72.17-121.83	72.17-130.33	
Test statistics		p =0.020	p < 0.0001		

Group effect: $F=77.38$, $p<0.0001$; Test effect: $F=87.44$, $p<0.0001$; Group \times test effect: $F=33.60$, $p<0.0001$

of re-cementation for zirconia restorations on abutments.⁵ In this study, the retention change between the first cementation and re-cementation were investigated. This was done after removing the zirconia copings with standard cement thickness that were produced on short titanium and zirconia abutments using the CAD/CAM procedure.

Short abutments were preferred in this study to better observe the factors related to retention. Carnaggio *et al.*¹ and Cano-Batalla *et al.*⁴ reported that abutment dimensions affect retention in implant-supported crowns. Small and short abutments have lower retention, which means that de-cementation is more likely to occur in short abutments. The results of this study revealed that lower strengths are sufficient for removal when a coping is re-cemented. This information shows that some precautions should be taken to increase retention, especially in restorations with short abutments. Several procedures have been introduced in the existing literature to increase crown retention.¹⁷⁻¹⁹ Various studies have reported that roughing the inner parts of the restorations increases retention.^{18,20} Some researchers have stated that roughing abutment surfaces via several methods increases crown retention.^{10,21} Although these procedures increase restoration retention, there are other factors that should be considered. The roughness of the abutment surface, which is provided in the first cementation procedure, may not be ensured in the following cementation procedure, for example. Aside from morphological changes, especially in thin titanium abutments and/or restorations, removing strength and increasing cement thickness can also affect retention after re-cementation. Expanding the cement thickness not only decreases mechanic retention but increases the exposure of adhesive material to saliva and other fluids that during feeding, which means that retention loss can occur in association with cement dissolution in the long term.^{22,23}

An inadequate number of studies have investigated bond strength and other characteristics of titanium and zirconia abutments.^{24,25} Joda *et al.*²⁴ compared titanium and zirconia abutments in terms of stiffness, strength and failure mode, and Foong *et al.*²⁵ compared them in terms of fracture resistance. It was found out in the present study that the bond strength of samples with zirconia abutments was higher than that of samples with

titanium abutments in the first test. The difference in bond strength between titanium and zirconia surfaces with cement material may have played an active role in this situation. In addition, minimal elastic deformation of the titanium material may have occurred during removal. Zirconia is a harder material than titanium.^{26,27} During the pull-out test, it may be more difficult for zirconia to break the mechanical linkage between the corners of the abutment surface and the coping inner surface. This may be the reason why higher bond strength values were found in samples with zirconia abutments during the pre-test. In addition, the main aim of this study was not to compare the bonding strength of samples with zirconia and titanium abutments but to reveal changes in bonding strength in the case of re-cementation. The effects of titanium and zirconia abutments on bonding strength should be investigated in comprehensive studies using specialized method stages with a higher number of samples design.

A higher retention loss was observed in samples with zirconia abutments than in samples with titanium abutments. There are no studies that have directly analyzed this subject; thus, this is a distinctive finding within the scope of the study. The hardness values of titanium and zirconia materials differ, and the cleaning process with a round head carbon steel bur and explorer may cause different effects on zirconia and titanium surfaces. In the less hard titanium structure, this cleaning process creates scratches, and the harder zirconia surface may be turned into a shiny and flat surface instead of the rougher surface that was originally produced.

In the present study, basic cleaning methods that can be applied in clinics were used in cleaning the surfaces of the zirconia and titanium abutments and zirconia copings before re-cementation. In a similar study, the copings were cleaned by placing them in an ultrasonic bath.⁵ The cleaning process can be carried out by both methods in clinical environments. In this study, the former method was preferred considering the fact that cleaning with an ultrasonic cleaning bath can be neglected during a fast workflow. In this context, the effect of different surface cleaning methods on bond strength should be comprehensively studied.

This study can be considered as a pilot study due to its various limitations. These limitations include things such as the absence of a thermal aging process and

failure mode evaluation. Generally, restorations are exposed to saliva and temperature changes in the mouth for a while before the de-cementation. Re-cementation is performed after this exposure. Within the limits of this study, no environment that imitates that of the mouth was created except in keeping the samples in distilled water for a day. Additional factors, such as heat changes, were not applied. In other words, the limitations of the study enable an evaluation of retention loss that is not dependent on these factors. Cement type and surface roughening procedures highly affect the retention of restorations.^{1,4} Future studies should investigate the effects of different adhesive cements, surface treatments, cleaning methods and thermal aging on retention after re-cementation.

CONCLUSION

Within the limits of the study, the following results were found: (1) Re-cementation may adversely affect the bond strength of single-unit restorations on short abutments. (2) In the case of re-cementation, a higher retention loss may occur in zirconia abutments than in titanium abutments.

REFERENCES

- Camaggio TV, Conrad R, Engelmeier RL, Gerngross P, Paravina R, Perezous L *et al.* Retention of CAD/CAM all-ceramic crowns on pre-fabricated implant abutments: an *in vitro* comparative study of luting agents and abutment surface area. *J Prosthodont* 2012;21:523-8.
- Covey DA, Kent DK, Germain Jr HAS, Koka S. Effects of abutment size and luting cement type on the uniaxial retention force of implant-supported crowns. *J Prosthet Dent* 2000;83:344-8.
- Kim Y, Yamashita J, Shotwell JL, Chong K-H, Wang H-L. The comparison of provisional luting agents and abutment surface roughness on the retention of provisional implant-supported crowns. *J Prosthet Dent* 2006;95:450-5.
- Cano-Batalla J, Soliva-Garriga J, Campillo-Funollet M, Muñoz-Viveros CA, Giner-Tarrida L. Influence of abutment height and surface roughness on *in vitro* retention of three luting agents. *Int J Oral Maxillofac Implants* 2012;27:36-43.
- Safari S, Hosseini Ghavam F, Amini P, Yaghmaei K. Effects of abutment diameter, luting agent type, and re-cementation on the retention of implant-supported CAD/CAM metal copings over short abutments. *J Adv Prost* 2018;10:1-7.
- Felton DA, Kanoy BE, White JT. Recementation of dental castings with zinc phosphate cement: effect on cement bond strength. *J Prosthet Dent* 1987;58:579-83.
- Ayad MF, Johnston WM, Rosenstiel SF. Influence of tooth preparation taper and cement type on recementation strength of complete metal crowns. *J Prosthet Dent* 2009;102:354-61.
- Simon RL. Single implant-supported molar and premolar crowns: a ten-year retrospective clinical report. *J Prosthet Dent* 2003;90:517-21.
- Bresciano M, Schierano G, Manzella C, Screti A, Bignardi C, Preti G. Retention of luting agents on implant abutments of different height and taper. *Clin Oral Implants Res* 2005;16:594-8.
- Sadig WM, Al Harbi MW. Effects of surface conditioning on the retentiveness of titanium crowns over short implant abutments. *Implant Dent* 2007;16:387-96.
- Ho R. Handbook of univariate and multivariate data analysis and interpretation with SPSS. 2nd ed. Florida: Chapman and Hall/CRC; 2006.
- George D, Mallery P. SPSS for Windows Step by Step: A Simple Guide and Reference. 10th ed. Boston: Pearson; 2010.
- Ayad MF, Rosenstiel SF, Woelfel JB. The effect of recementation on crown retention. *Int J Prosthodont* 1998;11:177-82.
- Pommer B, Zechner W, Watzak G, Ulm C, Watzek G, Tepper G. Progress and trends in patients' mindset on dental implants. I: level of information, sources of information and need for patient information. *Clin Oral Implants Res* 2011;22:223-9.
- Pommer B, Zechner W, Watzak G, Ulm C, Watzek G, Tepper G. Progress and trends in patients' mindset on dental implants. II: implant acceptance, patient-perceived costs and patient satisfaction. *Clin Oral Implants Res* 2011;22:106-12.
- Vichi A, Louca C, Corciolani G, Ferrari M. Color related to ceramic and zirconium restorations: a review. *Dent Mater* 2011;27:97-108.
- Sharma A, Rahul G, Poduval ST, Shetty K. Short clinical crowns (SCC)—treatment considerations and techniques. *J Clin Exp Dent* 2012;4:e230-6.
- Karimipour-Saryazdi M, Sadid-Zadeh R, Givan D, Burgess JO, Ramp LC, Liu P-R. Influence of surface treatment of yttrium-stabilized tetragonal zirconium oxides and cement type on crown retention after artificial aging. *J Prosthet Dent* 2014;111:395-403.
- Wandscher VF, Prochnow C, Rippe MP, Dorneles LS, Callegari GL, Baldissara P, *et al.* Retentive strength of y-tzp crowns: comparison of different silica coating methods on the intaglio surfaces. *Oper Dent* 2017;42:121-33.
- Nejatidanesh F, Savabi O, Jabbari E. Effect of surface treatment on the retention of implant-supported zirconium restorations over short abutments. *J Prosthet Dent* 2014;112:38-44.
- Kurt M, Külünk T, Ural Ç, Külünk Ş, Danişman Ş, Savaş S. The effect of different surface treatments on cement-retained implant-supported restorations. *J Oral Implantol* 2013;39:44-51.
- Carter SM, Wilson PR. The effect of die-spacing on crown retention. *Int J Prosthodont* 1996;9:21-9.
- Mehl C, Harder S, Steiner M, Vollrath O, Kern M. Influence of cement film thickness on the retention of implant-retained crowns. *J Prosthodont* 2013;22:618-25.
- Joda T, Bürki A, Bethge S, Brägger U, Zysset P. Stiffness, strength, and failure modes of implant-supported monolithic lithium disilicate crowns: influence of titanium and zirconium abutments. *Int J Oral Maxillofac Implants* 2015;30:1272-9.
- Foong JK, Judge RB, Palamara JE, Swain MV. Fracture resistance of titanium and zirconium abutments: an *in vitro* study. *J Prosthet Dent* 2013;109:304-12.
- Ho WF, Chen WK, Wu SC, Hsu HC. Structure, mechanical properties, and grindability of dental Ti-Zr alloys. *J Mater Sci Mater Med* 2008;19:3179-86.
- Kobayashi E, Matsumoto S, Doi H, Yoneyama T, Hamanaka H. Mechanical properties of the binary titanium-zirconium alloys and their potential for biomedical materials. *J Biomed Mater Res* 1995;29:943-50.

Yeniden simantasyonun CAD/CAM zirkonya kuronların kısa titanyum ve zirkonya abutmentler üzerine tutunmasına etkisi

ÖZET

AMAÇ: Bu çalışmanın amacı yeniden simantasyon işleminin bir self adeziv rezin siman ile kısa titanyum ve zirkonya dayanaklara yapıştırılan zirkonya kopinglerin tutuculuğuna etkilerinin karşılaştırmalı olarak değerlendirilmesidir.

GEREÇ VE YÖNTEM: Bu *in vitro* çalışmada 12 adet titanyum

(Nucleoss T4 implants, NucleOSS T4 flat abutment, İzmir, Türkiye) ve 12 adet zirkonya (Zirkonzahn, Zirkonzahn GmbH, Bruneck, İtalya) dayanak kullanıldı. Titanyum dayanakların boyu 3 mm'ye indirildi ve analoglara sabitlenerek akrilik içine gömüldü. Titanyum dayanaklar taranarak bilgisayar destekli tasarım ve imalat (CAD/CAM) yöntemi ile zirkonyum dayanaklar ve zirkonyum kopingler üretildi. Tüm zirkonyum kopingler bir self adeziv rezin siman ile titanyum ve zirkonyum dayanaklara simante edildi. Örnekler universal test cihazında pull-out testine tabi tutuldu ve bağlanma dayanımı değerleri kaydedildi. Dayanaklar ve kopingler üzerindeki siman kalıntıları anguldruvaya takılan bir çelik rond frez ve sond ile temizlendi. Kopingler yeniden simante edildi, tekrar pull-out testi uygulandı ve bağlanma dayanımı değerleri kaydedildi. Verilere tanımlayıcı istatistikler uygulandı, ortalama ve standart sapma değerleri elde edildi. Grup ve test etkisini karşılaştırmak için ikili karşılaştırmalı Bonferroni düzeltmeleri kullanıldı. $p < 0.01$ değerleri istatistiksel olarak anlamlı kabul edildi.

BULGULAR: Ön test ve son testin bağlanma dayanımı üzerindeki etkisi ($p < 0.001$), titanyum ve zirkonyum grup farklılığı

etkisi ($p < 0.001$) ve test-grup interaksiyon etkisi ($p < 0.001$) istatistiksel olarak anlamlı bulundu. Titanyum ve zirkonyum örneklerde ilk test ve ikinci test arasında bağlanma dayanımı açısından anlamlı farklılık gözlemlendi (Titanyum: $p < 0.05$, Zirkonyum: $p < 0.001$). Son test bağlanma dayanımı değerleri, öntest bağlanma dayanımı değerlerinden istatistiksel olarak anlamlı derecede düşüktü. İlk testten son teste bağlanma dayanımı değerlerinin değişiminde titanyum ve zirkonyum örnekler arasında anlamlı farklılık gözlemlendi, bağlanma değerlerindeki azalma zirkonyum örneklerde daha fazlaydı ($p < 0.001$).

SONUÇ: Yeniden simantasyon durumunda kısa dayanaklar üzerindeki tek üye restorasyonların retansiyonu olumsuz etkilenebilir. Resimantasyon durumunda zirkonyum dayanaklarda titanyum dayanaklara göre daha fazla tutuculuk kaybı oluşur.

ANAHTAR KELİMELER: Diş implantı; titanyum; yapıştırma; zirkonyum