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Effect of Abutment Design and Methods for Controlling on the Amount of Residual Luting Agent Around the Margins of Implant Restorations

Abutment Tasarımı ve Siman Kontrol Yöntemlerinin İmplant Üstü Kuronlarda Oluşan Artık Siman Üzerine Etkisi

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ABSTRACT

Objectives: The aim of this study was to investigate the amount of excess cement after cementation using three different cement application methods and to compare the effect of two different abutment designs on the residual cement in cement-retained implant restorations.

Material and methods: A maxillary cast was used to simulate implant placement in the lateral incisor region. Implant analogs were embedded in the maxillary cast. The right lateral custom abutment was designed non-anatomically, and the left lateral custom abutment was designed anatomically with computer-aided design. After the screw channels were closed, a total of 80 monolithic translucent zirconia crowns were fabricated. Crowns were cemented with three different cementation techniques and without any technique in the control group. The amount of residual cement was measured by the computerized planimetric cement evaluation method.

Results: The lowest residual cement area was observed in the anatomic-teflon group, and the highest residual cement area was observed in the non-anatomic control group. In the anatomic abutment design group, there was no significant difference between the control and rubber dam group ($p>0.05$), but a significant difference was found between the control and other groups ($p<0.05$). In the non-anatomic group, statistically significant differences were found between the control and other groups ($p<0.05$).

Conclusions: The anatomic abutment design significantly reduced the amount of residual cement compared to the non-anatomic abutment design. It was concluded that PVS replica technique was the most effective cementation technique in terms of residual cement.

Keywords: *Abutment design, Cement-retained restoration, Excess cement, Residual cement.*

ÖZET

Amaç: Bu çalışmanın amacı, üç farklı simantasyon yönteminin artık siman miktarına etkisini araştırmak ve iki farklı abutment tasarımının siman tutuculu implant restorasyonlarında artık siman üzerindeki etkisini karşılaştırmaktır.

Materyal ve metot: Lateral kesici diş bölgesinde implant yerleşimini simüle etmek için bir maksiller model kullanıldı. İmplant analogları alçı model içine gömüldü. Sağ lateral bireysel abutment anatomik olmayan şekilde, sol lateral bireysel abutment ise bilgisayar destekli tasarım ile anatomik olarak tasarlandı. Vida kanalları kapatıldıktan sonra toplam 80 adet monolitik translusent zirkonya kron üretildi. Kronlar üç farklı simantasyon tekniği ve kontrol grubunda herhangi bir teknik kullanılmadan simante edildi. Artık siman miktarı bilgisayarlı destekli siman değerlendirme yöntemi ile ölçüldü.

Bulgular: En düşük artık siman alanı anatomik-teflon grubunda, en yüksek artık siman alanı ise anatomik olmayan kontrol grubunda gözlendi. Anatomik abutment tasarımı grubunda, kontrol ve rubber dam grubu arasında anlamlı fark bulunmazken ($p>0,05$), kontrol ve diğer gruplar arasında anlamlı fark bulundu ($p<0,05$). Anatomik olmayan grupta, kontrol ve diğer gruplar arasında istatistiksel olarak anlamlı farklar bulundu ($p<0,05$).

Sonuçlar: Anatomik abutment tasarımı, anatomik olmayan abutment tasarımına kıyasla artık siman miktarını önemli ölçüde azaltmıştır. PVS replika tekniğinin artık siman açısından en etkili simantasyon tekniği olduğu sonucuna varıldı.

Anahtar Kelimeler: *Dayanak tasarımı, Siman tutuculu restorasyonlar, Artık siman, Rezidüel siman.*

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Introduction

Implant-supported fixed prosthetic restorations can be retained to abutments either cement or screws. Both abutment options have advantages and disadvantages. In cement-retained restorations, the passive fit is easier to achieve because of the cement layer between the implant abutment and the restoration. In general, the risk of technical complications is higher for screw-retained implant restorations and the risk of biological complications is higher for cement-retained implant restorations. The higher risk of biological complications in cement-retained restorations has been associated with excess cement around the abutment. In a study on this subject, excess cement was detected in eighty percent of patients diagnosed with periimplantitis, and in the clinical follow-up of these patients, periimplantitis symptoms were completely resolved in 78 percent of the patients, although they did not apply any other periodontal treatment after removing only the cement remnant.[1] According to the consensus decision of the European Federation of Periodontology, it has been accepted that there is a connection between periimplantitis and excess cement.[2]

In cement-retained fixed restorations, the depth of the abutment is the most important factor affecting the amount of residual cement. If the abutment margins are below one mm. or more from the free gingiva, the risk of remaining cement residue increases. However, especially in the anterior region, the supragingival or gingival margin creates a problem in terms of aesthetics. In addition, vestibule and proximal gingival heights are not the same in the anterior region. Therefore, using a standard abutment will cause residual cement to remain in the proximal area, it is almost impossible to remove cement from this area. It is critical to produce a custom abutment with the right parameters, following the free gingiva, to avoid any residual cement.

For the cementation of implant-supported fixed restorations, some applications have been suggested in order to completely remove the residual cement or to prevent residual cement release around the abutment. Many studies have reported the positive effect of the extra-oral cementation technique to reduce the amount of excess cement.[3-5] A replica of the abutment was fabricated from materials such as pattern resin, thermoplastic materials, silicone, bis-acrylic, composite, and the crown was placed on this replica abutment prior to intraoral cementation. With this technique, it was tried to obtain the minimum amount of cement required for the retantion of the restoration. In addition, techniques such as isolating the surface of the abutment in contact with the soft tissue with materials such as teflon tape or rubber-dam have also been suggested by some researchers.[6-9] In the extra-oral cementation technique, the amount of excess cement can be minimized, but retention problems may occur in the implant crown. In order to reduce the decementation of the crown, it is necessary to prepare the resistance and retention of the abutment correctly. Resistance and retention can be adjusted in abutments that are individually manufactured using CAD-CAM technology. Preparing the abutment in the anatomical tooth form with an interoclusal angle will greatly increase the retention. Thus, the probability of decementation of the crown will decrease by using less cement. As in natural tooth preparation principles, when the surface area of a tooth covered with a cement film layer is greater, the retention of the restoration will be greater. Therefore, preparing the anatomical abutment both increases retention and allows less cement application.

The first aim of this study is to compare three different cementation methods in terms of residual cement in cement-retained implant restorations. The secondary aim of the study is to evaluate the relationship between abutment design and the amount and distribution of residual cement. The null hypothesis was abutment design and different cementation methods do not affect the amount of residual cement.

Materials and Methods

For sample size calculation, a power analysis was performed, and the required minimum specimens' size was N=10 (the 0.05 level with 80% power). A model obtained with a dental resin (Zortrax Resin Dental Model, Zortrax S.A, Poland) was used to simulate implant placement in the maxillary lateral incisor region. Implant analogs (MegaGen Anyone) were embedded in the maxillary cast. Custom wax patterns were fabricated for the gingival profile. Scan bodies were inserted and the cast was scanned, the right lateral custom abutment was designed non-anatomically, and the left lateral custom abutment was designed anatomically with computer-aided design (CAD), (Figure 1). Ti-base zirconia abutments' finish line was epigingivally. Abutments screwed onto implant analogs with a 35-Ncm torque according to the manufacturer's instructions. The screw channels were closed with

polytetrafluoroethylene (PTFE) tape and sealed with provisional restorative material (Cavit, 3M ESPE). Monolithic translucent zirconia crowns (Noritake Katana UTLM) were fabricated with a 25-µm cement space to standardize the cement amount (American Dental Association ADA specification No. eight for dental zinc phosphate cement guide to dental materials devices ADA, Chicago (1974), pp. 18-193). Monolithic translucent zirconia crowns were sintered in a high-temperature furnace.

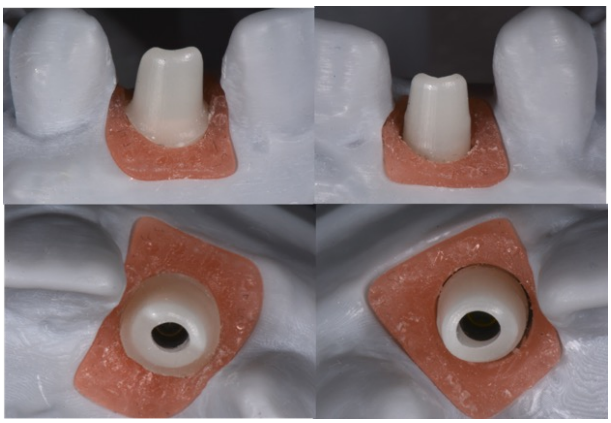

Fig 1. Occlusal and lateral views of anatomic and non-anatomic abutments

According to the abutment design and methods for controlling the amount of residual luting agent, the groups were set as follows:

Group 1: anatomic abutment design with no controlling technique (control group)

Group 2: anatomic abutment design and rubber dam

Group 3: anatomic abutment design and PTFE tape

Group 4: anatomic abutment design and polyvinyl siloxane replica

Group 5: non-anatomic design with no controlling technique (control group)

Group 6: non-anatomic abutment design and rubber dam

Group 7: non-anatomic abutment design and PTFE tape

Group 8: non-anatomic abutment design and polyvinyl siloxane replica

For the control group, none of the controlling techniques were used.

To fabricate a silicon replica, a light body form of polyvinylsiloxane (Affinis, Coltene) was placed into the crowns. After setting, the putty was removed. The internal surfaces of the crown were cleaned with a cotton swab soaked in 95% alcohol. The replica was modified with a surgical blade (No. 15; Swann Morton) in accordance with the protocol of Wadhwani et al.[10] The crowns were also filled with cement and cemented onto the silicone replica. The silicone replica was then removed.

For the rubber dam technique, a square sheet of rubber dam material was prepared and a hole was punched in the center of the sheet. The abutment was pushed through the hole in the rubber dam sheet and placed under the cementation margin of the crown abutment.

For the PTFE technique, a two-three cm long, 100 µm thick PTFE tape (UL yellow gas line tape; Seal Tape Inc) was used as a retraction cord. The PTFE band is wrapped under the gingival margin of the abutment and tied buccally to lingually.

After each technique, the zirconia crowns were cemented on the zirconia abutments with zinc polycarboxylate cement (Poly-F Plus, Dentsply, Germany). The cement was mixed and prepared according to the manufacturer's recommendations, and then the crowns were filled by using a syringe to standardize the amount. Each crown was seated with constant vertical finger pressure and waited for two minutes to allow to set the cement. Excess cement was removed using a dental floss and a probe (3CH Cowhorn; Hu-Friedy). After 24 hours, a hole for screw access was prepared on the palatal surface of each crown to retrieve the abutment with the crown. The screw was loosed using a screwdriver (Abutment Removal Driver, MegaGen), and the crown- abutment was removed.

A computer-assisted planimetric cement evaluation method described by Linkevicius et al.[9] was used. The same researcher (B.Y.) performed all cementation procedures. After cement removal, the photographs were taken with a digital camera (D3200; Nikon Corp) of all aspects (mesial, distal, buccal, and lingual) of the retrieved crown-abutment to asses the residual cement. All photographs were obtained at a constant magnification of 3:1 and same distance from the object. The photographs were imported and analyzed in a photoshop program (Adobe® Photoshop® CS5 Extended Version 12.0.4 ×64) with pixel area calculation. The number of pixels in each area was recorded and the percentage of the cement residual area of the total implant crown-abutment surface area was calculated. Remnant cement ratio (%) = (Remnant cement surface area/total abutment

surface area) × 100

The data were analyzed using a software program (SPSS V22.0 software, IBM Corp; Armonk, New York). The data were not distributed normally according to the Shapiro-Wilk test. Therefore, Kruskal Wallis, and a Mann-Whitney U test were performed to determine whether there were significant differences between the groups (α = .05).

Results

The total surface area values covered by the cement residues are shown in Table 1 for each group. The lowest residual cement area was observed in the anatomic-teflon group, and the highest residual cement area was observed in the non-anatomic control group. According to the results of the statistical analyses, there was a significant difference between non-anatomic control and anatomic control, non-anatomic teflon and anatomic teflon, non-anatomic rubber dam, and anatomic rubber dam groups (p=0.001). There was no significant difference between non-anatomic PVS and anatomic PVS groups (p=0.318).

Table 1. Amounts of excess cement for each group

Main group	Sub-group	N	Mean	Std. Deviation
Non-anatomic	CONTROL	10	181,72	91,53
	TEFLON	10	69,38	34,76
	RUBBER DAM	10	58,67	14,90
	PVS	10	11,72	8,98
Anatomic	CONTROL	10	17,52	5,08
	TEFLON	10	6,78	5,87
	RUBBER DAM	10	11,42	8,02
	PVS	10	7,28	5,58

When the non-anatomic group was evaluated within itself, statistically significant differences were found between the control and teflon group (p=0.004), control and rubber dam group (p=0.001), control and PVS group (p=0.01). There was no significant difference between the teflon and rubber dam groups (p=0.71). There was a statistically significant difference between teflon and PVS group (p=0.002) and rubber dam and PVS group (p=0.001). The amount of residual cement was lower in the PVS technique.

Considering the anatomic group within itself, statistically significant differences were found between the control and teflon group (p=0.007), between the control and PVS group (p=0.004). There was no significant difference between the control and rubber dam group (p=0.128). There was no statistically significant difference between the teflon and rubber dam group (p=0.165), teflon and PVS group (p=0.902), rubber dam and PVS group (p=0.383).

Discussion

The fabrication process, the low cost and the similarity of cement-retained implant restorations to tooth-supported restorations have led many clinicians to prefer these cement-retained crowns for implant restorations. Despite all these advantages, the main disadvantage of these restorations is the cement residue that flows into the surrounding soft tissue cannot be completely removed. Many techniques have been proposed to remove the residual cement, and most of these techniques have been shown to significantly reduce the amount of residual cement. However, the most effective and the easiest to apply clinically among these techniques has not yet been defined. Therefore, three different cementation methods were compared in this study. Statistically significant differences were found between the different techniques and the null hypothesis was rejected.

In the literature, creating a hole in the restoration for cement escape[11], and applying cement only on the occlusal or cervical third of the inner part of the restoration[12] are some methods that have been tried. The use of a gingival cord around the crown has been applied to prevent subgingival cement flow, but this method was found to be unsuccessful because the cord may enlarge the sulcus and cause the cement to flow deeper.[13] Therefore, the Teflon tape method, which is similar to the gingival cord method, was used in our study. Teflon tape does

not widen the sulcus because it occupies less than 50 μm when stretched. In addition, the Teflon tape surface can be easily removed from the peri-implant sulcus by adhering to the cement. The extra oral cementation technique uses a copy of the abutment. In this technique, the restoration is filled with cement and the restoration is placed on the copy abutment model. Excess cement is wiped off and the restoration is cemented onto the abutment in the mouth.[10] Chee et al.[14], using PVS replicas before cementation, reported that the least amount of residual cement was observed in the PVS mould technique. In the study by Bukhari et al.[15], the combination of PVS mould and rubber dam resulted in the lowest amount of residual cement. In our study, similar to other studies, the lowest amount of cement in the non-anatomic group was observed in the PVS technique.

In the present study, both different cementation techniques and two different abutment designs produced by CAD/CAM were compared. Especially in the anterior region, standard abutments are not preferred for aesthetic reasons and have a higher risk of cement residue. Linkevicius et al. reported that standard titanium abutments are usually too narrow, which leads to undercuts and makes cleaning difficult.[7,9] However, in a prospective randomized pilot study, Kappel et al.[16] compared full ceramic custom abutments with standard abutments in terms of cement residue. When comparing cement residue by surface, 68% of custom abutment surfaces and 30% of standard abutment surfaces were found to have residual cement. One reason for the higher amount of undetected cement in this study may be that custom abutments have larger surfaces, which may lead to more pressure on the gingiva during placement of the abutment and crown. Several in vitro and in vivo studies have shown that standard abutments cause more problems in cleaning the cement at the crown-abutment interface and lead to periodontal disease.[7,9,17] It has been reported that the amount of residual cement can be reduced with an anatomical CAD/CAM abutment design because it has a natural emergence profile and creates a marginal shoulder/chamfer edge.[18] Therefore, in this study, the effect of anatomic and non-anatomic CAD/CAM abutment designs on residual cement was compared. There is no previous study in the literature about the design of the abutment. In vitro and in vivo studies[7,9,19] have shown that deeper restoration margins are associated with greater amounts of subgingival residual cement, but these studies have always used standard abutments. Wasiluk et al. reported that custom abutments were more advantageous in terms of residual cement compared to standard abutments.[20] In our study, the amount of residual cement was significantly lower in the anatomic CAD/CAM group compared to the non-anatomic group.

Different methods have been reported in the literature to determine the amount of residual cement.[9,11,19] The radiographic evaluation method has been used in clinical studies, but it is not possible to see the residual cement on the buccal and lingual surfaces on radiographs. Therefore, it has been reported that dental radiographs should not be considered as a reliable method for cement residue assessment.[9,16] Other methods include taking microscopic images of the samples and making digital measurements, taking standard photographs, and calculating surface area values in pixels, and weighing the residual cement. The two-dimensional nature of microscopic and photographic measurements is the main disadvantage of the studies. In our study, we used two-dimensional area measurements over photographic images. In two-dimensional imaging, some of the cement seen in one region is also seen in the other region, which can lead to incorrect calculations. In order to eliminate this disadvantage, studies using three-dimensional measurements with more advanced techniques are needed.

The properties of the cement used also have a major impact on the relationship between cement residue and peri-implant disease. Agar et al.[21] showed that resin-based adhesive cements are more difficult to clean from the abutment surface than glass ionomer and zinc phosphate cements. Temporary cements have disadvantages such as higher solubility and lower retention compared to permanent cements. Therefore, polycarboxylate cement, which is easier to clean than resin cement and which is frequently used in the clinic for cementation of implant restorations, was preferred in the present study.

Conclusion

Within the limitations of this study; It was concluded that anatomic abutment design significantly reduced the amount of residual cement compared to the non-anatomic abutment design. In anatomic abutment design Teflon tape technique was the most effective cementation technique in terms of residual cement. However, in both the anatomic and non-anatomic abutment groups the least residual cement was found in PVS replica technique. In the control group, which was cemented without any cementing technique,

residual cement was observed significantly more than in other groups. Therefore, according to the results of this study, it can be recommended to apply any cementation technique for all abutment types in clinical conditions.

Conflict of interest

None of the authors of this article has any relationship, connection or financial interest in the subject matter or material discussed in the article.

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