ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

Comparison of Marginal Fit of Cobalt-Chromium and Zirconia Cores Fabricated by Different Techniques Before and After Cementation

Farklı Tekniklerle Üretilen Kobalt-Krom ve Zirkonya Korların Simantasyon Öncesi ve Sonrası Kenar Uyumlarının Karşılaştırılması

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ABSTRACT Objective: Marginal fit is one of the important factor for the long-term success of dental restorations. The purpose of this in vitro study was to compare the marginal fit of cobalt-chromium (Co-Cr) and zirconia cores fabricated by different techniques before and after cementation. **Material and Methods:** Forty standardized cores were fabricated with an internal space of 40 µm and thickness of 0.5 mm by different techniques (n=10/group). Co-Cr cores were fabricated by lost-wax casting and computer-aided design/computer-aided manufacturing (CAD/CAM) and zirconia cores were produced by copy milling and CAD/CAM techniques. Marginal gaps were measured at 60 points along the specimens circumferential margins by using a microscope before and after cementation. The data obtained were analyzed by using 1-way analysis of variance, Duncan's multiple-range post-hoc test, and paired t-test (p=0.05). **Results:** Before cementation, the cores fabricated by CAD/CAM showed the least marginal opening (p<0.05). After cementation, the marginal opening significantly increased among all the groups. **Conclusion:** CAD/CAM technique ensured a better marginal fit than the other techniques. Although the mean marginal gap values of all the copings were within the clinically acceptable limit (≤120 µm), cementation significantly increased the marginal openings of all the copings.

Key Words: Chromium alloys; zirconium oxide; dental marginal adaptation

ÖZET Amaç: Kenar uyumu diş restorasyonlarının uzun dönem başarısındaki önemli faktörlerden biridir. Bu in vitro çalışmanın amacı farklı tekniklerle üretilen kobalt-krom (Co-Cr) ve zirkonya korların simantasyon öncesi ve sonrası kenar uyumlarını karşılaştırmaktır. **Gereç ve Yöntemler:** Kırk adet standardize edilmiş 40 µm iç boşluğa ve 0.5 mm kalınlığa sahip korlar farklı tekniklerle üretildiler (n=10/grup). Co-Cr korlar kayıp mum ve bilgisayar destekli tasarım/bilgisayar destekli üretim (CAD/CAM) ve zirkonya korlar da kopya kazıma ve CAD/CAM teknikleri ile üretildiler. Kenar açıklıkları korların marjin çevresinde 60 noktadan mikroskop kullanılarak simantasyon öncesi ve sonrasında ölçüldü. Elde edilen veriler 1-yönlü varyans analizi, Duncan çoklu karşılaştırma testi ve paired t testleri ile analiz edildi (p=0,05). **Bulgular:** CAD/CAM'le üretilen korlar simantasyon öncesinde en az kenar açıklığı göstermiştir (p<0,05). Simantasyon sonrasında tüm gruplarda kenar açıklığı istatistiksel olarak önemli oranda artmıştır. **Sonuç:** CAD/CAM tekniği, diğer tekniklere göre daha iyi kenar uyumu göstermiştir. Tüm korların ortalama kenar açıklık değerleri klinik olarak kabul edilebilir sınır içerisinde olmasına rağmen (≤120 mm), simantasyon işlemi incelenen tüm korların kenar açıklıklarını önemli oranda arttırmıştır.

Anahtar Kelimeler: Krom alaşımları; zirkonyum oksit; dental marjinal adaptasyon

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In dentistry, cobalt-chromium (Co-Cr) is used for constructing fixed prostheses because of its lower cost, weight and suitability for different fabrication methods (e.g., conventional lost-wax casting and computer-aided design/computer aided manufacturing [CAD/CAM]).[1-4] Over the years, several all-ceramic systems have been developed.[5,6] These restorations offer excellent esthetics and have been successfully used for restoring anterior and posterior teeth.[7,8] One of the most important advances in dentistry has been the introduction of zirconia-based ceramic materials. Similar to metal-ceramics, zirconia-based restorations use a high-strength ceramic material for the substructure to provide sufficient resistance against cyclic loading.[9] Zirconia frameworks can be fabricated by milling a presinterized or fully sintered blocks using CAD/CAM.[4,10,11] In addition, they can be milled by a direct ceramic machining system (copy milling system) using presinterized blocks.[12]

Co-Cr or all-ceramic crowns fabricated by different techniques are used in clinical practice on the basis of the indications and cost, but the marginal fit is one of the most important criteria for their long-term success.[1,13] Poor marginal adaptation leads to dissolution of the luting agent, secondary caries, pulpal sensitivity, and reduced restoration longevity.[11,14-16]

The type of material used and fabrication technique might influence the marginal fit of the restoration. However, few studies of the marginal adaptation of both Co-Cr and zirconia crowns fabricated by different methods have been conducted.[12,17] In addition, clear evidence of the fabrication method that consistently provides a superior marginal fit is lacking. Therefore, the purpose of this in vitro study was to compare the marginal fit of Co-Cr and zirconia cores fabricated by different techniques before and after cementation. The following null hypotheses were tested: (1) The marginal fit of Co-Cr and zirconia cores were not influenced by manufacturing techniques. (2) There would be no differences in marginal fit values among the groups before and after cementation.

MATERIAL AND METHODS

Forty machined stainless steel dies were prepared in a lathe (Tessan, Czech Republic) to simulate crown preparations for a mandibular molar. The preparations were standardized as follows: height of 4 mm, chamfer finish, and total convergence angle of 6° (Figure 1). Then, forty 0.5-mm-thick cores with an internal space of 40 μm were fabricated by the same technician using 2 different materials and 3 different techniques (n=10/group; Table 1): Co-Cr cores were fabricated by lost-wax casting (CC-LW group) and CAD/CAM (CC-CC group), zirconia cores were fabricated by copy milling (Z-CM group) and CAD/CAM (Z-CC group).

FABRICATION OF CORES

CC-LW Group

The dies were relieved with 3 layers of spacer (mega-Stumpflack, megadental GmbH, Büdingen, Germany), applied 0.5 mm short of the margin. A steel template (Figure 2) was used to fabricate the cores in standard conditions. Wax patterns were

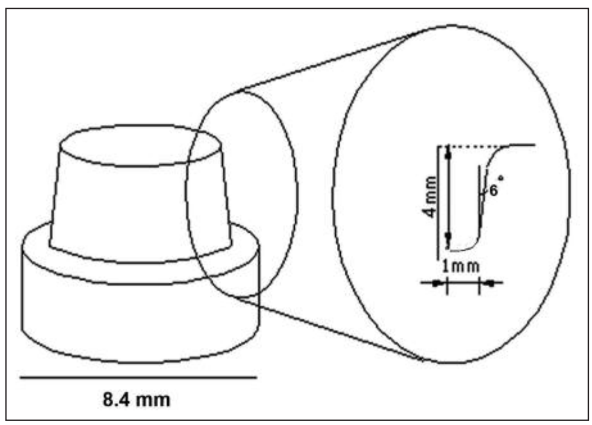

FIGURE 1: Illustration of a stainless steel die (mm).

TABLE 1: Mean and SD values (μm) of the marginal gaps in the experimental groups and the results of Duncan's test.

Group	N	Precementation Mean	SD	Postcementation Mean	SD
CC-LW	10	79,42[b]	24,31	97,51[bc]	20,40
CC-CC	10	43,29[a]	12,68	69,64[a]	22,84
Z-CM	10	92,52[b]	18,63	113,99[c]	22,80
Z-CC	10	57,17[a]	20,51	82,03[ab]	26,45

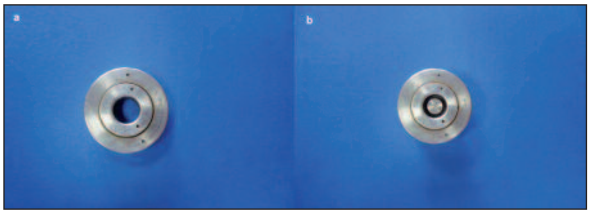

FIGURE 2: a. Stainless steel template; **b.** The template positioned on a stainless steel die.

prepared, invested with phosphate-bonded investment (Bellavest T, Bego, Bremen, Germany), and casted with a Co-Cr-based alloy (Kera C, Eisenbacher Dentalwaren ED GmbH, Wörth am Main, Germany) by using an induction vacuum/pressure casting machine (Inf-2010, Mikrotek Dental, Ankara, Turkey). Thereafter, the castings were cleaned with 110-µm aluminum oxide (Al_2O_3) particles by using an abrasion device (MKK-975, Mikrotek Dental, Ankara, Turkey).

CC-CC Group

In this group, all the dies were first scanned with the 3-D digital laser scanner of a dental CAD/CAM system (3Series, Dental Wings Inc., Montreal, Canada). The scanner's software program (DWOS Software, Dental Wings Inc.) converted the scanned data into 3-D CAD data. In the CAD process, modelling was performed on the digitalized dies. The cement thickness was set to 40 µm. Next, the data were transferred to a CAM unit, and the cores were milled from Co-Cr-based blocks (Kera NH, Eisenbacher Dentalwaren ED GmbH).

Z-CM Group

In this group, the cores were fabricated by using a pattern resin (T-Rigid, Zirkonzahn GmbH, Gais, Italy) on the dies with the guidance of a steel template. Then, they were fixed and processed by a manual milling unit (Zirkograph 025 ECO, Zirkonzahn GmbH, Gais, Italy) using partially sintered zirconium oxide blocks (Zirkonzahn, Zirkonzahn GmbH, Gais, Italy). They were finally sintered in an oven (Keramikofen 1500, Zirkonzahn GmbH, Gais, Italy) at 1500°C for 8 h.

Z-CC Group

They were fabricated in a similar manner to the CC-CC cores. After scanning and digitizing all the contours of the dies, the cores were milled from partially sintered zirconia blocks (Zirkonzahn). Subsequently, they were sintered in a special furnace (Keramikofen 1500) at 1500°C for 8 h.

After fabrication, the intaglio surfaces of all the cores were checked for fit with an occlusion spray (Okklufine Premium, FINO GmbH, Bad Bocklet, Germany). Fitting-surface interferences were eliminated with a small diamond bur (Mani Dia-Burs, Mani Inc., Tochigi-Ken, Japan) under copious water irrigation. Undercontoured cores or those with marginal deficiencies were excluded from the study and then, all the cores were marked with indelible marking pen before cementation.

CEMENTATION OF CORES

Before cementation, all the cores were thoroughly cleaned for 15 min with distilled water in an ultrasonic bath (BioSonic JR, Coltène/Whaledent Inc., OH, USA). Then, they were cemented to their respective dies with polycarboxylate cement (Poly F Plus, Dentsply DeTrey GmbH, Konstanz, Germany) under 10 N in a universal testing machine (TSTM 02500, Elista Elektronik İnformatik Sistem Tasarım Ltd. Şti., İstanbul, Turkey).

EVALUATION OF MARGINAL FIT

A special metal device fixed to the microscope was used to secure the cores at the same position on their respective dies (Figure 3). Therefore, the position of the specimens and the measurement location were standardized, ensuring that the maximal distance between the restoration margin and the

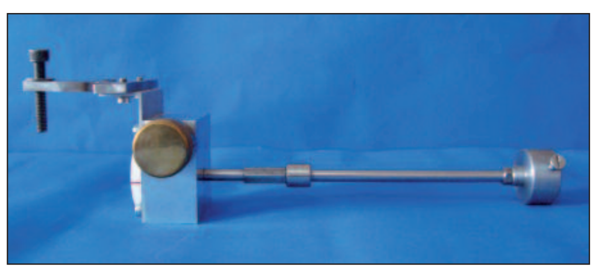

FIGURE 3: Metal device for marginal fit evaluation.

surface of the preparation was perpendicular to the optical axis of the stereomicroscope. The metal device consisted of a brass wheel. When the wheel was rotated half a turn, the sample rotated along 1/60th of its circumferential margin. Therefore, the marginal discrepancy of each core was measured at 60 points (every 44 μm) along its circumferential margin both before and after cementation. A microscope (Nikon Eclipse E400, Nikon, Tokyo, Japan) at ×40 magnification was used to locate marginal gaps and the images were recorded with a digital camera (Clemex 4.3 H Color, Clemex Technologies Inc., Longueuil, Canada) fitted on the microscope. The images were then exported to a computer and analyzed with an image-analyzing program (Clemex Vision Lite 3.5, Clemex Technologies Inc., Longueuil, Canada), which had been calibrated by an experienced engineer according to the manufacturer's instructions before the study. The marginal fit of each core was evaluated by measuring the gap between the edge of the core and the margin of the die at same points both before and after cementation (Figure 4). The mean value of 60 measurements represented the mean marginal gap value (μm) of each core. All the measurements were performed by the same investigator.

STATISTICS

The data were analyzed by using 1-way analysis of variance (ANOVA) and Duncan's multiple-range post-hoc test. In addition, a paired t-test was used to compare the precementation and postcementation values within the groups. The level of significance was set to 0.05 for all the tests.

RESULTS

The mean and standard deviation values (μm) of the marginal gaps of the cores and the results of Duncan's test are reported in Table 1. Both before and after cementation, the CC-CC and Z-CM groups had the lowest and highest mean marginal gap values, respectively. One-way ANOVA revealed significant differences (df=3, F=12.80, p<0.00) in the vertical marginal adaptation before cementation among the groups. The CC-CC and Z-CC groups showed lower marginal gap values than

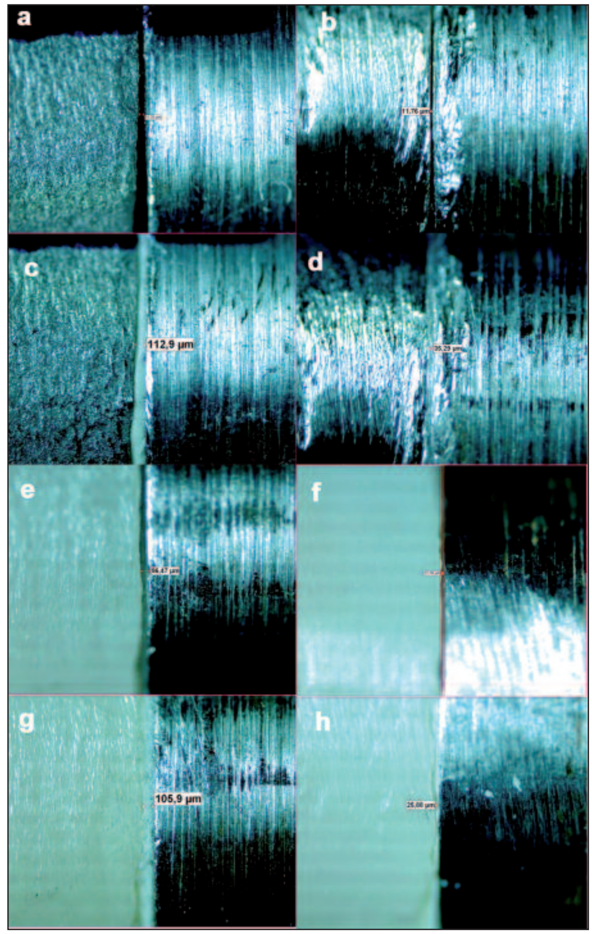

FIGURE 4: Marginal fit of the copings before **(a, b, e, f)** and after **(c, d, g, h)** cementation (×40 magnification)
a, c: CC-LW group; **b, d:** CC-CC group; **e, g:** Z-CM group; **f, h:** Z-CC group.

the other groups (p<0.05). After cementation, significant differences among the groups (df=3, F=6.84, p<0.001) were again recorded. Duncan's test showed significant differences between the CC-LW and the CC-CC, the CC-CC and the Z-CM, and the Z-CM and the Z-CC groups. The paired t-test also revealed significant differences in the marginal gap values before and after cementation in the groups (Table 2; p<0.05).

DISCUSSION

In this in vitro study, the marginal fit of Co-Cr and zirconia cores fabricated by different techniques was assessed before and after cementation. The null hypotheses were rejected that marginal fit of Co-Cr and zirconia cores were influenced by the man-

TABLE 2: Results of the paired t-test.

	Post-precementation			
Group	Mean	SD	t Value	P
CC-LW	18,08	15,92	3,59	0,006*
CC-CC	26,35	18,96	4,39	0,002*
Z-CM	21,46	16,98	3,99	0,003*
Z-CC	24,86	20,89	3,76	0,004*

ufacturing technique and differences were found in marginal fit values among the groups before and after cementation.

In this study, stainless steel dies were used as abutments because of the advantages of standardized preparation and lack of wear during core fabrication and measurement.[17-21] According to Groten et al., approximately 50 measurements along the margin of a crown are sufficient to yield clinically relevant information.[22] Sixty microscopic measurements were made along the entire margin of each abutment, therefore the number of measurements in this study was sufficient to determine the mean marginal gap values. Most authors agree that a marginal gap between 100 and 120 μm is clinically acceptable.[23-26] The mean marginal gap values of the cores in this study were therefore within the clinically acceptable range.

The cores fabricated by CAD/CAM showed significant differences in the marginal fit when compared with the conventionally fabricated and copy-milled cores before cementation. Therefore, CAD/CAM ensured the best marginal fit. This is in agreement with other studies.[12,17] This difference might be explained by some of the factors as follows. In the current study, the frameworks were fabricated with a predetermined internal space of 40 μm. In CAD/CAM, the internal space was adjusted during the manufacturing process; however, standardizing the thickness of die spacers during lost-wax casting and copy milling is difficult. Furthermore, in lost-wax casting and copy milling, the dental technician influences the marginal adaptation of fixed restorations during the fabrication procedures. To minimize some of these factors, the same technician fabricated the cores. Another explanation is the use of different digitization systems such as a laser scanner for CAD/CAM, in contrast to a mechanical scanner for copy milling.

Although a standardized load (10 N) was applied during cementation, the marginal discrepancy significantly increased after cementation in all the groups, as previously reported.[27-29]

This study has some limitations that stainless steel abutments do not provide information about the microstructure of teeth after preparation or about the mechanical and/or chemical adaptation of the luting material to dentin. In addition, only the marginal fit was assessed, and the internal fit of the cores was not evaluated. Clinical trials are needed to validate these results.

CONCLUSION

Within the limitations of this study, the following conclusions can be drawn:

- Regardless of the material used, the cores fabricated by CAD/CAM had a better precementation marginal fit than those fabricated by lost-wax casting or copy milling.
- Cementation significantly increased the marginal discrepancies of all the cores.
- The marginal gap values of the cores were within the clinically acceptable limit (≤120 μm).

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