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MARGINAL, AXIAL, AND OCCLUSAL MISFIT ASSESSMENT OF LASER-SINTERED METAL AND ZIRCONIA COPINGS FABRICATED WITH DIGITAL AND CONVENTIONAL IMPRESSION TECHNIQUES

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ABSTRACT

Background and Aim: The purpose of this in vitro study was to elucidate the effect of different impression techniques on the marginal, axial, and occlusal misfit of laser-sintered metal (M) and zirconia (Z) copings.

Material and Methods: Forty similarly sized extracted human maxillary premolar teeth were prepared and randomly divided into 4 groups (n=10): (1) M copings fabricated with conventional impressions (CI), (2) M copings fabricated with digital impressions (DI), (3) Z copings fabricated with CI, (4) Z copings with fabricated DI. The marginal, axial, and occlusal misfits of these copings were measured with the silicone replica technique under a stereomicroscope at a magnification of ×30, and the data were analysed with 2-way ANOVA (α= 0.05).

Results: The mean marginal misfit values were 92.0 µm for the Group CI-M, 50.1 µm for the Group DI-M, 75.8 µm for the Group CI-Z, and 47.7 µm for the Group DI-Z. The copings produced with the DI technique showed lower marginal, axial, and occlusal misfits than those fabricated with the CI technique ($p<0.001$). Although Z copings fabricated with the CI technique ($p<0.001$) had lower marginal and occlusal misfits than those of the M copings, different coping material and its fabrication process did not affect in the DI technique ($p\geq0.05$). No axial misfit differences were found between the M and Z copings for both impression techniques ($p\geq0.05$).

Conclusion: The copings fabricated with the DI technique showed lower misfit than those of the copings produced with the CI technique.

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CLINICAL DENTISTRY AND RESEARCH 2019; 43(1): 17-22 Orijinal Araştırma

DİJİTAL VE GELENEKSEL ÖLÇÜ YÖNTEMLERİ İLE ÜRETİLEN LAZER SİNTER METAL VE ZİRKONYA ALT YAPILARIN MARJİNAL, AKSİYEL VE OKLUZAL UYUMSUZLUKLARININ DEĞERLENDİRİLMESİ

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ÖZ

Amaç: Bu çalışmanın amacı farklı ölçü tekniklerinin metal lazer sinter (M) ve zirkonya (Z) altyapıların marjinal, aksiyel ve okluzal uyumsuzlukları üzerindeki etkisini değerlendirmektir.

Gereç ve Yöntem: 40 adet benzer ebattaki maksiller 1. Premolar çekilmiş insan dişi prepare edildi ve rastgele 4 farklı gruba ayırıldı (n=10): Geleneksel ölçü yöntemi (CI) ile elde edilen M altyapılar (1), dijital ölçü yöntemi (DI) ile elde edilen M altyapılar (2), geleneksel ölçü yöntemi (CI) ile elde edilen Z altyapılar (3), dijital ölçü yöntemi (DI) ile elde edilen Z altyapılar (4). Elde edilen altyapıların marjinal, aksiyel ve okluzal uyumsuzlukları 30× büyütme altında bir stereomikroskop yardımıyla ölçüldü ve sonuçlar çift yönlü ANOVA ile değerlendirildi (α=0.05).

Bulgular: CI-M grubundaki ortalama marjinal uyumsuzluk değeri 92 µm iken DI-M grubunda bu değer 50.1 µm; CI-Z grubunda 75.8 µm ve DI-Z grubunda 47.7 µm idi. DI yöntemi ile elde edilen altyapıların marjinal, aksiyel ve okluzal uyumsuzlukları CI yöntemi ile elde edilen altyapılardan anlamlı derecede daha düşüktü ($p<0.001$).

CI tekniği ile elde edilen Z altyapılar M altyapılardan daha düşük marjinal ve okluzal uyumsuzluk göstermesine rağmen, DI tekniğinde her iki altyapı arasında anlamlı farklılık bulunmamaktaydı ($p\geq0.05$). Aksiyel uyumsuzluk bakımından her iki altypı arasında her iki ölçü tekniği bakımından anlamlı farklılık bulunmamıştır ($p\geq0.05$). En yüksek okluzal uyumsuzluk değeri CI-M grubunda görüldü ve 233.2 µm idi.

Sonuç: DI tekniği ile üretilen altyapıların uyumsuzluk değerleri CI yöntemi ile elde edilen altyapılardan daha düşüktür.

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INTRODUCTION

Although the increase in the use of ceramic restorations has run parallel to the aesthetic expectation of patients,[1] metal-ceramic restorations are still widely used in the fabrication of fixed partial dentures (FPDs).[2] Computer aided impression-computer aided design-computer aided manufacturing (CAI-CAD-CAM) techniques have been developed and are widely used to fabricate FPDs. Although challenging because of the gag reflex of patients, the need for local anaesthesia for the movement of tissues, and the risk of damaging the soft tissues,[3] the conventional impression (CI) making technique was used to produce dental restorations until the improvement of digital impression systems.[4] The shortcomings and deficiencies in CI techniques can be eliminated with the DI systems that have recently been developed.[5,6]

Adaptation to an abutment tooth is one of the most important factors for the success and longevity of FPDs.[1] Large marginal misfits can adversely affect restorations by increasing gingival problems, the risk of secondary caries, and the dissolution of luting cement.[6,7] However, low axial and occlusal adaptations of FPDs may result in mechanical failure.[8] The misfit of FPDs fabricated with recently introduced CAI-CAM-CAD systems still needs to be evaluated.

The purpose of this in vitro study was to elucidate the marginal, axial, and occlusal misfit of M and Z copings fabricated with CI and DI techniques. The null hypothesis was that no differences would be found in the misfit of restorations fabricated with different impression techniques.

MATERIAL AND METHODS

Forty human maxillary first premolar teeth of similar size, without caries or defects, and extracted for orthodontic reasons were used. Institutional approval was obtained from Pamukkale University, Medical School Clinical Research Ethics Committee. The teeth were prepared for a full coverage restoration with 4 to 6 degrees of convergence angle and a 1-mm-wide chamfer circumferential finish line located 0.5 mm above the cemento-enamel junction (Figure 1). The teeth were then randomly divided into 4 equal groups. The groups were as follows: M copings fabricated with the CI technique (CI-M), M copings fabricated with the DI technique (DI-M), Z copings fabricated with the CI technique (CI-Z), and Z copings fabricated with the DI technique (DI-Z). For the

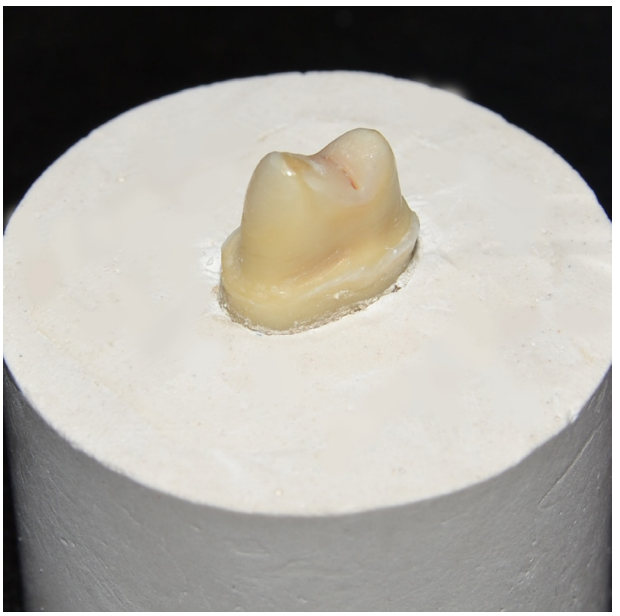


Figure 1. View of prepared tooth

Groups CI-M and CI-Z, two-step impressions of 20 teeth were made with a polyvinyl siloxane impression material (Variotime; Heraeus Kulzer GmbH), and Type IV dental stone (Fujirock; GC Corp) was poured into the impressions according to the manufacturer's instructions. For the Groups DI-M and DI-Z, DIs were made of the remaining 20 prepared teeth with the 3Shape Trios-3 intraoral scanning system (Standard-P12; 3Shape A/S) (Figure 2).

All the copings were designed digitally at a thickness of 0.5 mm with 20 µm of simulated die spacer starting 1 mm from the preparation margins by using the same CAD program (DWOS; Dental Wings). The zirconia copings were fabricated from high translucent presintered Z blocks (ICE Zircon Translucent; Zirkonzahn SRL) with milling machines (CEREC MC XL Mill; Sirona Dental Systems), and the M copings were produced from cobalt-chromium powder with the laser sintering machine (Eosint M 270; Eos GmbH).

To measure the marginal, axial, and occlusal misfit, the silicone replica technique was used.[7] Light-body silicone (Xantopren L Blue; Heraeus Kulzer GmbH) was placed in the copings, which were then seated on their corresponding teeth and held in place until the impression material had polymerized under an apically directed 50-N load. The copings were removed from their corresponding teeth. The light-body silicones in the copings were supported by another light-body silicone (Variotime; Heraeus Kulzer GmbH) to prevent deformation. When it had polymerized,

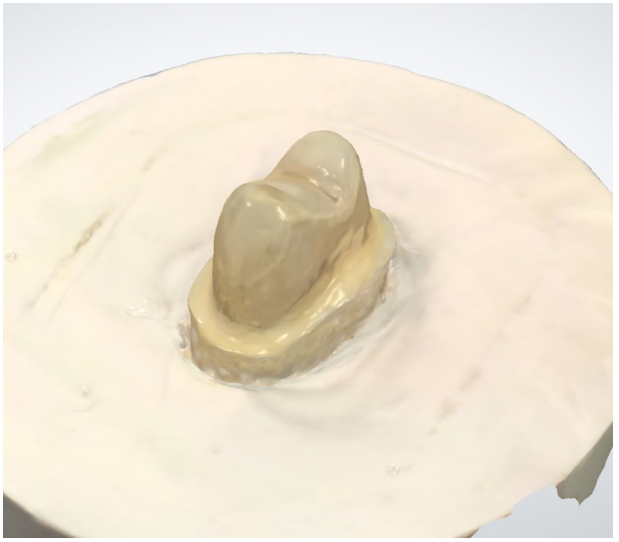


Figure 2. View of DI image

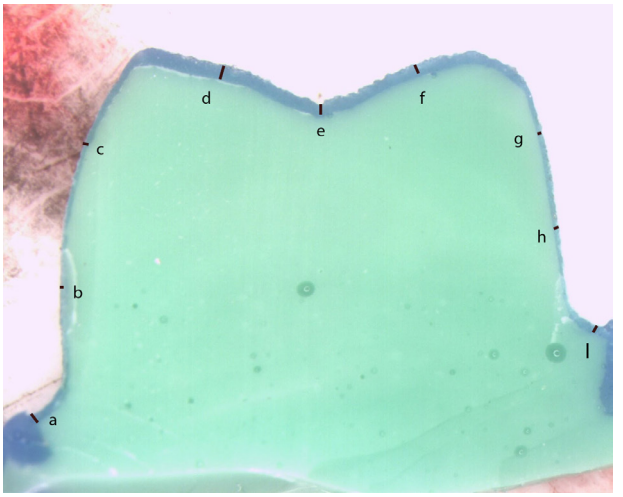


Figure 3. Sagittal section of the silicone replica: a, ı: marginal misfit measurement points; b, c, g, h: axial misfit measurement points; d, e, f: occlusal misfit measurement points

the 2-layered silicone body was removed from the copings. Each silicone replica was sectioned into 4 equal pieces, mesiodistally and buccolingually. Photographs of silicone slices were made with a stereomicroscope (Nikon SMZ 1500; Nikon Corp) with a magnification of ×30. Measurements on the photographs were made from each area at the same points with a computer program (Vision Lite; Clemex Technologies Inc). In total, 18 measurements were made for each coping as follows: 4 for marginal, 8 for axial, and 6 for occlusal misfits, and the average values were obtained (Figure 3). The data were analyzed with 2-way ANOVA (α=0.05). Statistical analyses were performed by using a software program (SPSS v20; IBM Corp).

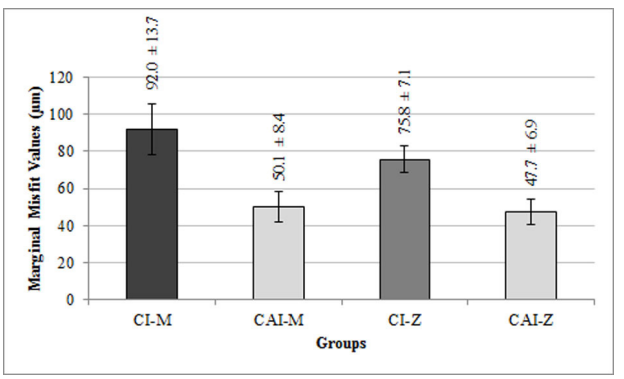


Figure 4. Results of mean (±SD) marginal discrepancy values (µm) [Different colored columns represent a statistically significant difference (p<.05)].

RESULTS

The 2-way ANOVA showed interactions between the coping fabrication protocols and impression techniques in the marginal and occlusal misfit values (p=0.027, p=0.038), while no interaction was detected in the axial misfit (p=0.301). Regarding the marginal misfit, Z copings had a lower misfit than M copings when the CI technique was used (p<0.001). However, when the DI technique was used, no statistically significant difference was found (p=0.569). The copings fabricated with the CI technique revealed larger marginal misfits than those of the DI technique (p<0.001) (Figure 4).

Regarding the axial misfit, the copings fabricated with the CI technique showed a larger axial misfit than those fabricated with the DI technique (p<0.001). However, no statistically significant difference was found between the Z and M copings for both impression techniques (p=0.533) (Figure 5).

Regarding the occlusal misfit, the Z copings had a lower misfit than the M copings when the CI technique was used (p<0.001), although no statistically significant difference was found between the copings when the DI technique was used (p=0.412). However, all copings fabricated with the CI technique had larger occlusal misfits than those fabricated with the DI technique (p<0.001) (Figure 6).

DISCUSSION

The data obtained in this study support the rejection of the null hypothesis that no differences would be found in the misfit of restorations fabricated with different impression

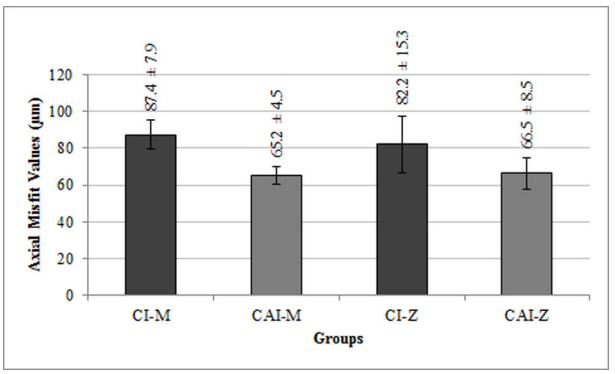


Figure 5. Results of mean (±SD) axial discrepancy values (µm) [Different colored columns represent a statistically significant difference (p<.05)].

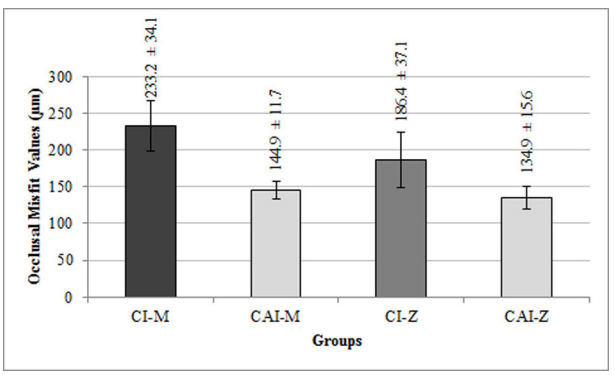


Figure 6. Results of mean (±SD) occlusal discrepancy values (µm) [Different colored columns represent a statistically significant difference (p<.05)].

techniques. The Z and M copings fabricated with the DI technique had lower marginal, axial, and occlusal misfits than those of the CI technique. Hence, the DI technique may eliminate the problems of distortion of the impression material while removing the prepared tooth from the impression, deformation of the cast, and incorrect casting of the mold.[9]

A wide range of marginal, axial and occlusal misfit values exist among published reports. [6,8,9] However, no consensus yet exists on the maximum marginal, axial, and occlusal misfits of full coverage restorations. This may be because different study methodologies used different die and coping materials and different scanning and milling devices,[3,9] making comparison difficult. In a study by Paradies et al.[10] that comparing zirconia-ceramic single crowns using digital and conventional measurement methods, the mean marginal space widths were slightly higher than some of the literature reported in the marginal region. [11,12] These values are also significantly higher than the values obtained from the current study. This could be due to Paradies' study specimens being finished crowns with veneered porcelain, whereas Syrek et al.,[11] Habib et al.[12] and in this study only used the copings to measure the fit. Adding porcelain to copings can cause distortion and lead to an inadequate fit according to Pak et al ., [13] whose results of two different zirconia systems (presintered and totally sintered milling) showed significant differences when analyzing the marginal gaps before and after porcelain veneering. Although the numerical values differ, in all studies including this study DI restorations had a significantly better fit than the CI groups at every site analysed.[10,11] Previous studies have suggested that a marginal misfit of up to 100 or 120 µm is clinically acceptable.[1,7,14] In this study, marginal misfit values were between 50.1 and 92 µm. These were similar with the previous studies.[9,15,16]

Large axial and occlusal misfits could cause polymerization shrinkage stresses with a thick layer of a cement material and could negatively affect the placing of the restorations.[8] A previous study reported a decrease in the fracture strength of porcelain crowns with a cement thickness of more than 70 µm.[17] May et al.[8] recommended 50 to100 µm for occlusal misfit through finite element analysis. They stated that bonding benefits were lost at a thickness approaching 450 to 500 µm because of polymerization shrinkage stresses. However, the study of May et al.[8] might not reflect clinical conditions because their study was based on the finite element analysis. In addition, some authors reported that internal misfits of up to 130 to 150 µm were clinically acceptable.[18,19] Therefore, no consensus exists on the optimum axial and occlusal misfit values of these restorations in the current literature. More studies should be performed on this topic.

In this study, the marginal, axial, and occlusal misfit of M and Z copings fabricated with CI and DI techniques were evaluated. This study has several limitations. The first limitation was that only two kinds of copings were evaluated. The effect of veneering ceramic on the marginal, axial, and occlusal misfit was not evaluated. Moreover, since this study was carried out in in vitro conditions, the effects of intraoral conditions on the marginal, axial, and occlusal misfits of the restorations still remain unknown.

CONCLUSIONS

Within the limitations of this in vitro study, the following conclusions were reached:

1. The metal and zirconia copings fabricated with the DI technique had lower marginal, axial, and occlusal misfits than those fabricated with the CI technique.
2. All the copings had clinically acceptable marginal misfit values.

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