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# Evaluation of Marginal Fit of Metal Core Fabricated by 3D Printing technique, milled wax/lost wax technique and Conventional lost wax technique

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**Keywords:**
Marginal fit, 3D Printing technique milled wax/lost wax technique, Conventional lost wax technique.

**ABSTRACT**

The high strength metal ceramic crowns have been extensively used in dentistry However, the fit is the most encountered problems in porcelain fused metal crowns. This mainly depends on the fabrication technique. The purpose was to compare the marginal fit of three techniques: direct laser metal sintering (DLMS) and milled wax with lost wax method (MWLW) and Conventional lost wax method. Thirty Cobalt-Chromium dies of dimension 5-mm height and a 0.5-mm chamfer finish line with a 12-degree angle of occlosal convergence. thirty dies were divided into three groups containing 10 samples each. All 30 dies were scanned using (Medit) scanner and data were used to fabricate metal copings using Laser sintering technique (Group-1), milled wax with lost wax method (Group-2) and Conventional lost wax method (Group-3). The study was done directly scanned under stereomicroscope at 50 x magnification for marginal fit evaluation. Differences in marginal gap were noted. Laser-sintered showed significantly smaller spaces between coping and abutment than milled wax/lost wax copings While the spaces was greater in the Conventional lost wax method. Laser-sintered Co-Cr crown copings showed better marginal fit than copings produced by milled wax/lost wax technique and Conventional lost wax technique.



## 1. INTRODUCTION

Metal ceramic restoration are still the most common used for fixed prosthodontic such as crowns and bridges. In addition to The development of science and the entry of technology into all the details of our daily lives led to the entry of new methods in dentistry and the innovation of methods in the manufacture of prostheses. Among these methods is the manufacture of metal-ceramic crowns using the 3D printing method and milled wax with lost wax method. Although these methods are important, they are still new and lack confidence that can be used clinically. And because the success of the restorations is mainly related to the marginal fit, it is necessary to evaluate it in the new techniques that have appeared recently. The aim of this study was to evaluate and compare the marginal fit in vitro of single crowns using three different fabrication methods using 3d printing, milled wax with lost wax method and Conventional lost wax method.

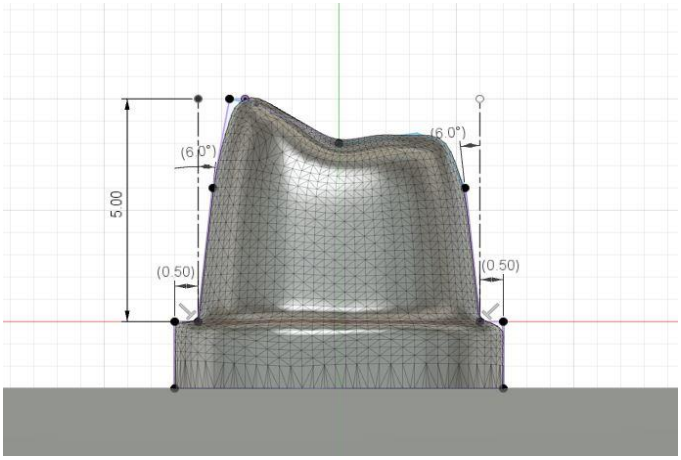


**Figure 1:** The tooth designed like prepared upper premolar and the dimensions for each model in 3D designing software.

## 2. Material & Methods

**Fabrication of models:**

One premolar tooth model were designed as having 360° chamfer preparations with 12° total occlusal convergence, with 3D designing software thirty premolar models were produced with the 3D printer. The premolar model was designed as a maxillary first premolar. All models were standardized and prepared for the fabrication of crowns. ten of the master models were used for fabrication of crowns using three different technique as a conventional lost wax method (CLW), Milled wax with lost-wax method (MWLW), and 3d printing method (Direct Laser Metal Sintering (DLMS)). The working models for CLW group were coated with three layers of die-spacer Each layer was approximately 10 μm with a total thickness of 30 μm according to previous studies.

In total, 30 single premolar crowns were fabricated using these different production techniques with 10 specimens in each group.

**conventional lost wax method(CLW):**

**obtaining frameworks:**

Only in CLW frameworks was used. These frameworks were reproduced from master models. For this instance, impressions were used. Impressions were made using simultaneous dual-mix impression technique from 10 master models using condensation silicone material. Type IV stone was poured into the impressions under vibration.

**Obtaining crown:**

Milled wax with lost-wax method (MWLW):

The master models were scanned(medit). After scanning, the modeling of the crowns was designed. The cement film thickness was set to 30 μm with no space 0.5 mm from the margin. CAD was sent to CAM machine for production using 3Shape CAD design software(GMAXX). The casting technique and other steps were performed similarly to that described above for the CLW method.

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**Figure 2:** wax pattern fabricated by (MWLW) method.

**3d printing method (Direct Laser Metal Sintering (DLMS)).**

The same CAD procedures were performed for the laser sintering. A laser sintering machine (SISMA MYSINT 100) The density of the laser was 2–10 cm3/h depending on the material The thickness of the sintered layer is 0.02–0.08 mm.

**Figure 3:** metal copings fabricated by (DLMS) method.

**Measurement of marginal gap:**

The measurement was done using the direct measurement method under the stereomicroscope. The magnification was placed 50 times, then pictures were taken in a similar position for all samples, with a reference sample being photographed in the same position, then the marginal gap was measured by the imagej program.

Three random points on each surface were measured and the mean was taken.

**Data management and statistics:**

Statistical analyses were carried out using the SPSS 20 software. One-way ANOVA was performed for statistical analysis among the techniques ($P < 0.05$).

**3. RESULT**

The results showed that significant differences when measuring the marginal gap, it were the DLMS copings showed significantly smaller spaces than both either the MLW and CLW copings.

The tables below show the results and statistical tests:

**Table 1:** Mean values of marginal fit for all measurement of all three production methods.

| | DISTAL (mean) | | | MESIAL (mean) | | | BUCCAL (mean) | | | LINGUAL (mean) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CLW | MWLW | DLMS | CLW | MWLW | DLMS | CLW | MWLW | DLMS | CLW | MWLW | DLMS |
| **1** | 106 | 90 | 82 | 80 | 93 | 78 | 83 | 90 | 83 | 75 | 90 | 81 |
| **2** | 101 | 52 | 39 | 93 | 55 | 30 | 96 | 85 | 42 | 97 | 80 | 38 |
| **3** | 108 | 100 | 48 | 97 | 81 | 50 | 117 | 85 | 50 | 93 | 89 | 44 |
| **4** | 111 | 65 | 44 | 103 | 77 | 48 | 109 | 91 | 48 | 100 | 92 | 35 |
| **5** | 109 | 59 | 45 | 100 | 56 | 63 | 108 | 67 | 61 | 109 | 75 | 60 |
| **6** | 105 | 73 | 53 | 87 | 69 | 49 | 94 | 80 | 43 | 99 | 89 | 47 |
| **7** | 113 | 89 | 48 | 113 | 84 | 45 | 100 | 81 | 50 | 89 | 93 | 35 |
| **8** | 115 | 99 | 53 | 107 | 73 | 45 | 103 | 83 | 43 | 106 | 100 | 60 |
| **9** | 107 | 91 | 56 | 100 | 83 | 56 | 106 | 88 | 53 | 108 | 101 | 35 |
| **10** | 109 | 101 | 46 | 113 | 90 | 55 | 95 | 84 | 62 | 101 | 90 | 54 |

**Table 2:** Mean values and standard deviation of marginal gap values according to specific measured locations using three fabrication techniques.

| | | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound | | |
| DLMS | | 10 | 51.40 | 11.853 | 3.748 | 42.92 | 59.88 | 39 | 82 |
| MWLW DISTAL | | 10 | 81.90 | 18.156 | 5.742 | 68.91 | 94.89 | 52 | 101 |
| | CLW | 10 | 108.40 | 4.033 | 1.275 | 105.51 | 111.29 | 101 | 115 |
| | Total | 30 | 80.57 | 26.684 | 4.872 | 70.60 | 90.53 | 39 | 115 |
| DLMS | | 10 | 51.90 | 12.618 | 3.990 | 42.87 | 60.93 | 30 | 78 |
| MWLW MESIAL | | 10 | 76.10 | 13.008 | 4.114 | 66.79 | 85.41 | 55 | 93 |
| | CLW | 10 | 99.30 | 10.636 | 3.363 | 91.69 | 106.91 | 80 | 113 |
| | Total | 30 | 75.77 | 22.901 | 4.181 | 67.22 | 84.32 | 30 | 113 |
| DLMS | | 10 | 48.90 | 15.014 | 4.748 | 38.16 | 59.64 | 35 | 81 |
| MWLW LINGUAL | | 10 | 89.90 | 7.894 | 2.496 | 84.25 | 95.55 | 75 | 101 |
| | CLW | 10 | 97.70 | 10.188 | 3.222 | 90.41 | 104.99 | 75 | 109 |
| | Total | 30 | 78.83 | 24.402 | 4.455 | 69.72 | 87.95 | 35 | 109 |
| DLMS | | 10 | 53.50 | 12.501 | 3.953 | 44.56 | 62.44 | 42 | 83 |
| MWLW BUCCAL | | 10 | 83.40 | 6.786 | 2.146 | 78.55 | 88.25 | 67 | 91 |
| | CLW | 10 | 101.10 | 9.620 | 3.042 | 94.22 | 107.98 | 83 | 117 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Total | 30 | 79.33 | 22.152 | 4.044 | 71.06 | 87.61 | 42 | 117 |

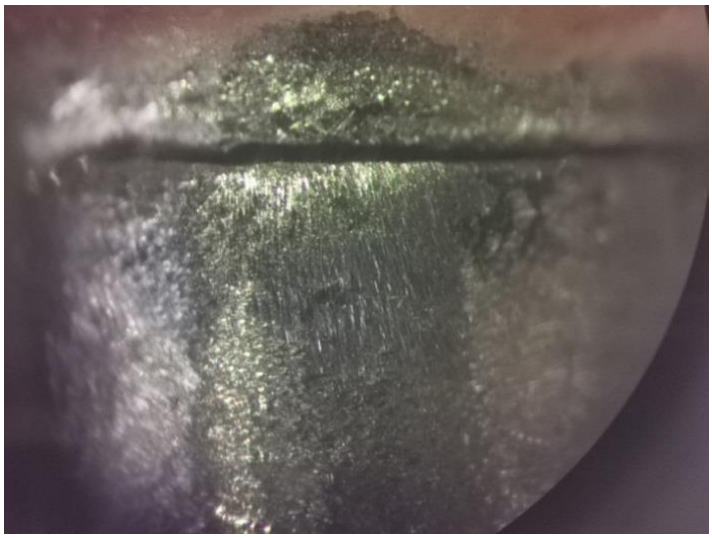

**Figure 4:** stereomicroscope image of the MWLW method (Buccal view)

**Figure 5:** stereomicroscope image of the DLMS method (Buccal view)

**4. Discussion**

Correct marginal fit is considered one of the most important factors that help the success of prosthodontics due to its impact on the durability of the prosthesis and the dental health and periodontal tissues. however Poor marginal fit causes predispose secondary caries, pulpal damage and periodontal problems. Several different methods were described to analyze and evaluate the marginal fit of the restorations in previous studies.

Most of the investigators used a single master die and subsequently used working die using impressions. The shortcoming of this technique is the impact of impression taking on the reproducing of the working die. Therefore, a standardized die was designed, reproduced for 30 dies, and fabricated by 3D printer(sisma mysint 100).

**Discussion of materials and methods:**
This study was conducted on die fabricated by 3D printing machine in order to standardize the samples. The research sample consisted of 30 die of prepared upper first premolar, and they were divided into 3 groups.

The copings are made by 3 different methods which are (DLMS), (MWLW)and (CLW).

A pilot study was conducted to test the best method for measuring the marginal gap. Samples were cemented and examined under a microscope, but this method led to difficulty seeing due to the excesses of the adhesive. A mounting base was designed to hold the coping and die in the same position for all samples during the measurement under the stereomicroscope

Measurement was done under the stereomicroscope by the direct method in order to preserve the safety of the samples for use in another test. Measurement was done on the marginal gap by ImageJ program.

**Discuss search results:**
The results showed that the amount of the marginal gap in the distal wall was (39-82) in the 3D printing method, (52-101) in the (MWLW) method, and (101-115) in the (CIW) method.
while she was in the mesial wall (30-78) in the (DLMS) method, (55-93) in the (MWLW) method, and (80-113) in the (CIW) method.
In the lingual wall (35-81) in the (DLMS) method, (75-101) in the (MWLW) method, and (75-109) in the (CIW) method.
in the buccal wall (42-83) in the (DLMS) method, (67-91) in the (MWLW) method, and (83-117) in the (CIW) method.
From the above, we conclude that the smallest value was in the (DLMS) method, then in the (MWLW)method, and then in the (CLW)method.
Previous studies relied on the fact that the clinically acceptable marginal gap is 120 μm, and that the CAD-CAM method gives an marginal gap of approximately 100 μm.

**Table 3:** one-way ANOVA test.

ANOVA

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Distal | Between Groups | 16271.667 | 2 | 8135.833 | 50.179 | .000 |
| | Within Groups | 4377.700 | 27 | 162.137 | | |
| | Total | 20649.367 | 29 | | | |
| Mesial | Between Groups | 11235.467 | 2 | 5617.733 | 38.169 | .000 |
| | Within Groups | 3973.900 | 27 | 147.181 | | |
| | Total | 15209.367 | 29 | | | |
| lingual | Between Groups | 13744.267 | 2 | 6872.133 | 52.654 | .000 |
| | Within Groups | 3523.900 | 27 | 130.515 | | |
| | Total | 17268.167 | 29 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Buccal | Between Groups | 11576.867 | 2 | 5788.433 | 58.892 | .000 |
| | Within Groups | 2653.800 | 27 | 98.289 | | |
| | Total | 14230.667 | 29 | | | |

## 5. Conclusion

In conclusion, within the limitation of this study, the best marginal fit was in 3d printing group(DLMS), followed by CAD/CAM (MWLW) and the conventional(CLW) method. The best fit was found in mesial wall in (DLMS); the larger gap was found in buccal wall in(CLW). All fabrication methods used in this study can be used for single crowns; however, because of The marginal fit was better with statistically significant differences in (DLMS) We recommend using it for single crown manufacturing.

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