# Marginal Fit of Metal Copings Fabricated from Digital and Conventional Impression Methods: an *In Vitro* Study

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**Abstract**

The impression method plays a major role in success and longevity of restorations. Accuracy of digital and conventional impressions can be evaluated by assessing the marginal fit of the prosthesis.

The current study compared the vertical marginal fit of metal copings fabricated by digital and conventional impression methods. DMLS copings made by digital and conventional impression methods were investigated. Twenty-three samples were prepared for each group from a single master die. The marginal discrepancy was studied by measuring gap between the coping margin and master metal die finish line using measuring microscope at four locations: mesial, distal, buccal, palatal. Measurements were made to determine the vertical component of marginal gap at the four locations using 46 copings fabricated from digital and conventional impressions.

Measurements were obtained from these 46 samples by observing 184 images (23 copings per group). DMLS metal copings made by digital impression method showed lesser marginal gap compared with that fabricated by conventional method in all four points measured. There were statistically significant differences between the two groups at mesial, buccal and lingual site. At the distal site though the marginal discrepancy was low (112.4±19.1 µm) it was not significant compared to the conventional impression method (211.6±28.9 µm).

Within the limitations of the *in vitro* study the digital impression technique was found to be more accurate than conventional impression. Further studies in clinical settings could substantiate the current observation.

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## Introduction

The accuracy of dental impressions is crucial for the long-term success of a restoration. Marginal adaptation of the crown is essential for maintaining gingival health and protecting tooth from physical, chemical, thermal and bacterial insult. Poor marginal adaptation in fixed prostheses leads to cement dissolutions, increased plaque retention and subsequent changes in the sub gingival microbial flora leading to periodontal disease, and secondary caries.[1] The accuracy of the marginal adaptation is measured by marginal gap and is affected by various factors such as the tooth preparation, final impression technique, properties of impression materials, master cast production, fabrication methods and materials used for restoration, and the material and method used for cementation.[2,3] Most investigators used the marginal gap criteria established by McLean and von Fraunhofer,[4] who concluded that a maximum of 120 µm is acceptable. Values between 50 and 200 µm are reported with the absence of an objectively accepted threshold.[5]

The impression technique plays an important role in marginal fit of crowns. Conventional impression materials and techniques were used successfully to fabricate fixed restorations. [6] However, the conventional impression procedures have drawbacks, such as patient discomfort, the need for storage of the materials and trays, mixing of the impression materials and disinfection.[7] Voids and bubbles in

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the impression, impression material separated from trays, embedded retraction cords and preparation debris cause difficulty in making accurate cast.[7-10] Distortion of casts can occur due to variable temperature and humidity.[11] It has been reported that impressions sent to laboratories sometimes have more than 50% of the preparation finish line indiscernible.[12]

The concept of intraoral digital impression was put forward in the early 1980s. Digital impression and technique are alternatives in the fabrication of dental restorations.[13,14] The development strategy of digital techniques included automating the production process and optimizing the quality of restorations. The digital workflow includes digital impression, digital design and digital manufacturing. Intraoral scanners (IOSs) have made possible a complete digital workflow, and several studies have confirmed that they produce clinically acceptable images.[14-18] The use of intraoral digital scanner to create virtual impression has allowed clinicians to eliminate the use of impression materials, identify preparation margins, check interocclusal space and design prostheses. The digital methodology involves the capture of an image of the prepared tooth, adjacent and opposing teeth, to create a three-dimensional data file. This file is then utilized to design the crown. The transfer of digital impression does not require disinfection, land transportation or fabrication of gypsum cast for articulation. Thus, the potential for dimensional inaccuracies could be eliminated.[19,20]

There are a number of advantages for digital impressions if it can be implemented in daily dental practice. It is therefore crucial to also obtain information on the accuracy of such systems during *in vivo* use. One of the problems associated with the digital impression is that the scanners are optical systems that only record visible areas. Thus, blood especially saliva; combined with subgingivally located finish lines substantially complicate the scanning process.[21] Both digital and conventional techniques have advantages and limitations. The dentists play a major role in selecting the ideal method depending on the clinical situation and patient's preference. It can be predicted that the digital impression techniques will eventually be adopted for the impression procedures of inlays, onlays, crowns and FPDs. There are studies in the literature comparing overall patient preference, operator's preference, overall time, marginal fitness, internal fitness and repeatability of digital and conventional impression techniques.[22, 23] In this study, the marginal fit of metal copings prepared with the digital impression technique was compared with conventional impression technique in an *in vitro* model.

## Materials and methods

This study was carried out at the department of prosthodontics, KMCT Dental College, Calicut. The study was approved by the scientific Review Committee and Institutional Ethics Committee (IEC) of the KMCT, Calicut, Kerala, India.

### Preparation of the master die

A stainless-steel master die of 6mm height, 8 mm diameter with 1mm chamfer finish line, and 6-degree taper was fabricated. The master die had bevel of 45 degree on one side for reorientation of crown after fabrication. The metal die was mounted in acrylic base which was embedded in plaster of Paris enclosed in metal box (Figure 1)

**Figure1.** The custom fabricated master die used in the study.

### Preparation of samples for conventional impression technique

The conventional impression technique was performed using individually designed impression trays made using auto polymerizing acrylic resin over the wax spacer. Holes were placed on each side of the impression trays to allow egress of impression material which also

acted as a locking mechanism to prevent dislodgement of materials. An adhesive for VPS impression material was applied to the trays 5-10 minutes before impression. Auto mixing single step double mix putty wash impression technique was used to make 23 impression using Poly Vinyl Siloxane (3M ESPE, Germany) impression material. The impressions were set under clamp pressure for 5 minutes at room temperature and were examined for tears and voids. Type IV die stone (Kalrocks, Kalabhai Karson, Mumbai, India) were mixed to ensure a homogenous mix. The resultant mixture was then poured into the impression. The stone cast were scanned (D-2000, 3Shape Scanner, Copenhagen, Denmark), and the images were converted to stereolithography (STL) format to produce 23 STL file for 23 stone casts.

**Preparation of samples for digital impression technique**

A digital scanner (TRIOS®, 3Shape Copenhagen, Denmark) was used to make digital impressions of the master model. After starting with 3Shape system the same operator used the scanner to scan the study model 23 times, according to the operating instructions. The appropriate software produced the digital images as STL files for 23 samples

**Fabrication of direct metal laser sintering (DMLS) copings**

Design software (3Shape, Copenhagen, Denmark) was used to design the virtual framework based on the 46 STL files of the 2 groups. Design parameters were set at a cement gap of 0.04mm. The virtual frameworks were converted to 46STL files. From these files 46 DMLS copings were made using EOSINT M270 laser machine. No adjustments were made to the copings after fabrication.

**Measurement of marginal discrepancy**

A total of 46 DLMS Copings prepared for the evaluation. Twenty-three samples were by conventional impression method and 23 samples by digital impression method (Figure2). Each of the metal coping was reseated on the master die. A clamp attached to a pressure gauge was used to hold the copings on the master die and to give 19.6N/m2 pressure during measurement. Marginal discrepancy measurements for all the copings were carried out using measuring microscope at 20x magnifications (Mitutoyo MF-2010D, Mitutoyo, Kawasaki, Japan). Gap between the margins of the restoration and the finish line of the master die were measured at 4 reference points (buccal, lingual, mesial and distal) previously marked on the metal die. Marginal gap was measured at four predetermined sites. The measurements were obtained from these 46 samples by observing 184 images (2 groups, 23 copings per group, 4 sites per copings). The Statistical Package for Social Sciences (IBMSPSS, IBM SPSS Statistics for Windows, version 21, IBM Corp., Armonk, N.Y., USA) software was used to analyze the results obtained in this study.

**Figure 2.** The metal copings fabricated from conventional and digital impressions.

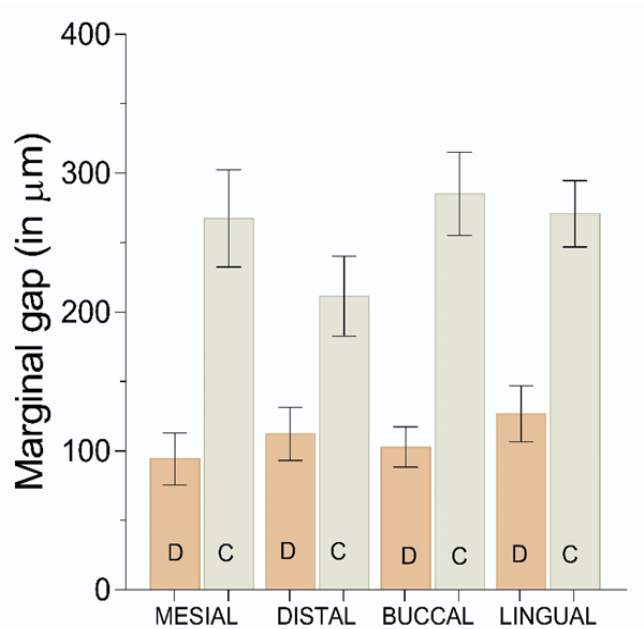


**Figure 3.** The marginal gap observed in the copings fabricated using digital and conventional impression method (D-Digital C-Conventional).

## Results

The marginal gap measured for both groups at four points were depicted in Table 1 and Figure 3. The marginal gap measurements of digital impression group were lower than that for conventional impression group. DMLS metal copings made by digital impression method showed lesser marginal gap compared with that fabricated by conventional method in all four points measured. There were statistically significant differences between the two groups at mesial, buccal and lingual site. At the distal site though the marginal discrepancy was low (112.4±19.1 µm) it was not significantly lower than the conventional impression method (211.6±28.9 µm). For the conventional methodology group the largest marginal gap measured was at the buccal site. For the digital methodology group lingual surface had largest marginal gap (Fig 3). The mean vertical gap measurement for the digitally produced copings was lower than that measured for the conventionally produced copings.

| Impression Method | Mesial | Distal | Buccal | Lingual |
|---|---|---|---|---|
| | Mean ±SEM | Mean ±SEM | Mean ±SEM | Mean ±SEM |
| Digital | 94.5±18.9 | 112.4±19.1 | 103±14.4 | 126.9±20.4 |
| Conventional | 267.7± 35.1 | 211.6±28.9 | 285.3±30 | 270.8±23.9 |
| p value | <0.001** | 0.009 | <0.001** | <0.001** |

**Table 1.** Mean vertical marginal discrepancy in digital impression methodology group (in µm), (Mann-Whitney U test) (*p<0.05; statistically significant) (**p<0.001; statistically highly significant).

## Discussion

This *in vitro* study evaluated vertical marginal accuracy of metal copings made by conventional and digital impression methodology. The potential errors were minimized through the following methods.

1. All the copings were made from a single stainless-steel master die after conventional and digital impression and marginal gap measurement were carried out after repositioning them on the master die
2. Conventional impressions were made by giving equal pressure during impression making using a clamp attached to a pressure gauge.
3. All the measurements were done by a single examiner in a similar environment.

The type of cement influences the marginal adaptation. In this study, the absolute marginal discrepancy was measured without permanent cementation to eliminate the influence of cementation on marginal adaptation. DMLS technology was selected for fabrication of all copings because it exhibits minimum marginal gap when compared with conventional lost wax technique. In this method computer makes virtual cross section of the 3- dimensional data obtained in the digital scan and uses a machine to print each layer one on top of other. It compensates for casting shrinkage and increased precision without any chance for manual error during fabrication process. Coping thickness, coping design and cement thickness can be standardized with this method. The mean marginal gap of digital methodology groups fell within clinically acceptable limits of 120 µm.[4]

Previous studies comparing the marginal fit showed that ceramic crowns fabricated from digital impression had a better fit than conventional impression.[24-28] There was no salivary flow or humidity during scanning process. Finish line is visible. Dimensional changes of impression materials, expansion of dental stone and error during lab transportation were eliminated. These all may be the reason for better marginal fit of digital impression methodology group. However, some of the studies concluded that accuracy of digital impressions was similar to that of conventional impression.[26, 29-32] A study by An et al [33] disclosed that the marginal gap between the restoration and definitive cast base metal die was greater in the groups that used the digital impressions compared to the conventional impression method which is supported by several other studies.[33-36]

The limitations of this study were that measurements obtained *in vitro* may not reflect the conditions found in the oral environment. Another factor that was not accounted for this study was the difference between room temperature and the oral cavity, how that would affect accuracy of the conventional impression technique needs investigations. *In vivo* studies should be conducted to evaluate the result of this study in a clinical application. In this study no single crown was entirely free of discrepancy and for this reason it would be recommended that

more measurement points be utilized or that a complete circumferential evaluation of the entire vertical opening be performed. This study only investigated the vertical marginal gap; however other parameters such as horizontal gap and internal fit could be evaluated. In addition, the study focused on the fabrication of a single crown. Thus, future studies should evaluate the use of this technology in more complex restorative procedures This study evaluated the relationship of the cavosurface finish line to the coping margin by evaluating marginal gap without focusing on inter- and intra-arch relationships. Occlusal contacts and proximal contact points with adjacent teeth are important factors that contribute to the acceptability of the final prosthesis, however, because these factors do not directly affect the integrity of fit both internally or at the margin, it was not considered in this study. Future studies should be conducted which would evaluate these parameters, which contribute to the overall clinical acceptability of a final prosthesis. In this study, point measurements of the prosthesis fit were made using digital software. However, a volumetric measurement would perhaps yield a more complete picture of the marginal gap circumferentially. Future research in this area should consider the use of tomography or other radiographic means to measure volume of the marginal gap, which as such could include more parameters such as horizontal discrepancy.

## Conclusions

Within the limitations of this study, it can be concluded that the marginal fit of metal copings fabricated by digital impression techniques were found to be more accurate than those fabricated by conventional techniques. Further studies in clinical settings could substantiate the current observation.

## Declaration of Interest

The authors report no conflict of interest and the article is not funded or supported by any research grant.

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