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# Evaluation of marginal adaptation and internal fit of maxillary complex provisional bridge manufactured by two different methods: An *In-vitro* study

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**Abstract**
**Aim:** The purpose of this in vitro study was to evaluate if the marginal discrepancy and internal fit of maxillary complex provisional bridge is improved by either 3D printing or CAD/CAM fabrication technique
**Methodology**: In the present study a total of sixteen samples (Eight in each group) fabricated by two methods using same STL file. Eight samples were fabricated from Telio CAD by Subtractive CAD CAM method (ARUM 5X- 400 Milling machine) (Control group), the other Eight samples were fabricated from HARZ Labs Dental Sand liquid resin by additive 3D printing (Anycubic photon S printer) (intervention group). All samples were tested for marginal gap by Digital microscope and internal fit was tested by silicon replica technique.
**Results:** It was found that regarding marginal adaptation and internal fit results; no statistically significant difference between the` fabrication methods.
**Conclusion:** Marginal fit and internal adaptation of (Additive three dimentional printing and Subtractive milling) fabrication techniques were within clinically acceptable ranges.
**Clinical implication**: Both' (Additive. and. subtractive) techniques could be used for provisional bridge fabrication

**Keywords:** 3D printing, additive, subtractive, milling, CAD/CAM, marginal fit and internal adaptation

## Introduction
A dental prosthesis is used to restore oral function and aesthetics when replacing missing teeth, this allows the preservation and improvement of the patient's appearance, comfort, physical and mental health. variety of treatment methods are available for restoring missing teeth dependent on the number and state of remaining teeth, existing space, bone support, expense, and'patient desire. (Abduo *et al*., 2014) [1].

The standardised digital systems have efficiently substituted the conventional impressions by the optical impressions and the casting techniques were substituted by the computer aided designing (CAD) and the computer aided manufacturing (CAM). Even in a digital system, it is necessary to create a functional model in order to determine and correct the restoration's fit. In addition, the working model will allow for improved restoration planning and design, as well as the combination of conventional and digital techniques. (Dureja *et al*., 2018) [6]

Three dimensional printing began to enter this field in order to solve some of the shortcomings of the milling technique. Additive manufacturing produces precise accurate prosthesis by minimal materials and less cost. Additionally, multiple restorations can be fabricated simultaneously. However, the primary disadvantage of this method of production is the co-occurring dimensional discrepancy that can manifest in the final model or restoration as various forms of clinical inaccuracy due to shrinkage during the building process and post-curing. (Jeong *et al*., 2018) [9].

## Material and methods
In a dentate typodont model maxillary central and lateral incisors were prepared by free hand

using depth grooves, with 2mm incisal reduction, 1.5 mm axial, and finish line 1'mm circumferential deep chamfer. Maxillary first premolar prepared by free hand using depth grooves, with 1.5 mm on buccal cusp and 2mm on palatal cusp, 1.5mm axial, with a finish line 1mm deep chamfer. Through tapered; stone with rounded; end size 13 (TR 13), size 14 (TR14), needle stone and football stone. any sharp areas that might performe as a point for stress concentration were rounded by the fine grit 852F. Rubber base index and graduated periodontal probe were used to confirm preparation thickness. Figure (1)

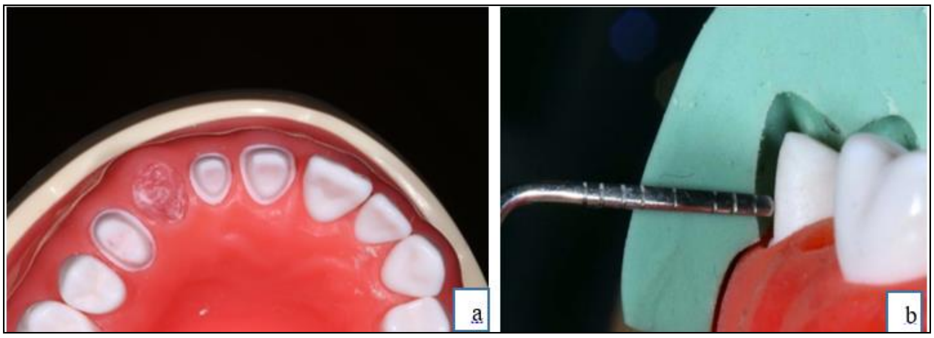


**Fig 1:** a) Finished and polished prepared abutments, b) Confirmation of preparation thickness using periodontal probe with the rubber base index.

Digital impression was taken by Medit i500 intra-oral scanner. The same STL file was used for designing both 3D printing and subtractive milling technique using ExoCad software. Figure (2)

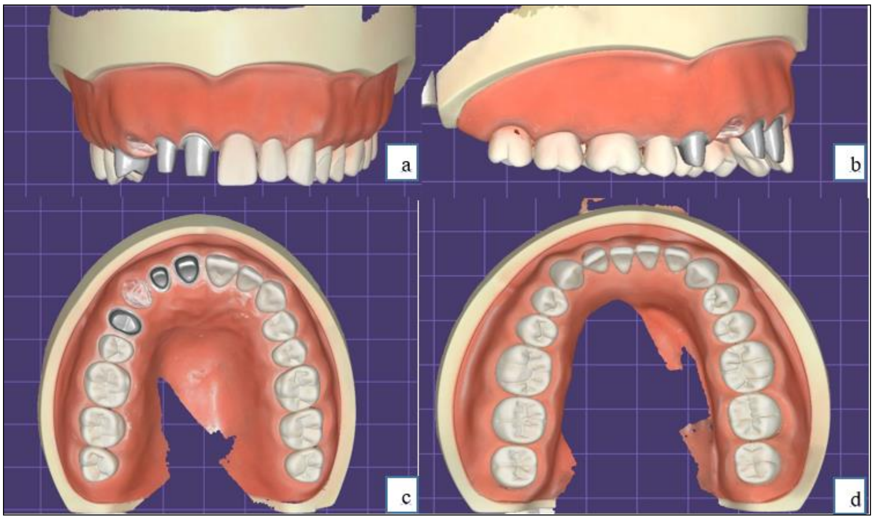


**Fig 2:** Digital scans to the typodont. a), b) prepared abutmnets buccally, c) prepared abutmnets occlusally, d)opposing mandibular arch.

A total of sixteen samples (eight in each group) were used in the present study. Group (I): included eight bridges (n=8) fabricated by CAD/CAM (control). Group (II): included eight bridges (n=8) fabricated by 3D printing (Intervention). The provisional bridges in the two group were numbered from 1 and ascending to 16, each sample was placed in an opaque sealed envelope, then were divided by (www.random.org) website into 2 equal groups in order to measure marginal fit and internal adaptation of two provisional bridges corresponding to each other randomly. External assessor was blinded (Single blind). Assessor received 16 sealed envelopes without knowing whether it belong to control or intervention group for randomization.

**Measurements**

**Measurement of marginal gap** was done by placing provisional bridges on the master die and fixed in place using special holding jig that help in hoding each specimen throughout the process of gap evaluation. Measurments were taken in microns by a compatible personal computer using a fixed magnification of X40 attached with built in camera that was also connected to US digital microscope. Each sample was photographed. Shots of the margins taken for each specimen. Shots were used in order to make morphometric measurements, Three equidistant landmarks along the cervical part of each specimen. Figure (3)

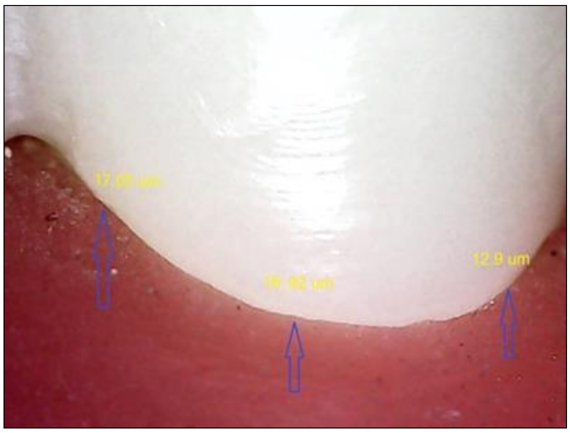

**Fig 3:** Photograph of 3D printed FDPs on the typodont abutment under digital microscope

Measurement of internal fit was done by a replica technique. On the intaglio of provisional bridges light body silicone (Elite, Zhermach, Italy) was added and seated into prepared abutments on the cast by finger pressure. Once light body silicone compelete set, provisional bridge was removed. heavy-body silicone was used to stabilize the light-body silicone. Replicas were carefully sectioned into four equal segments by a razor blade (n°. 15c). To measure internal fit Two opposite sections were used. Figure (4)

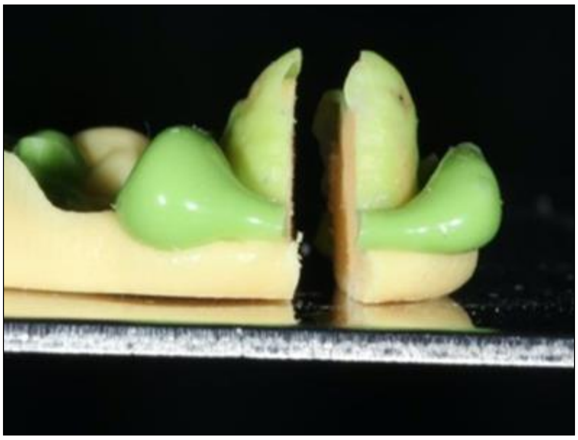

**Fig 4:** Two opposite sections of the same replica.

Four regions were evaluated on each seactioned replica (axial wall, finish line, inciso \ occluso-axial and incisal \ occlusal), giving eight internal measures for each replica. At 25 × magnification Using built in camera (U500 X Digital Microscope, China) and USB digital microscopy, measurments were taken in microns.

**Results**

The results were found using Graph Pad Instat (Graph Pad, Inc.) software for windows. A value of P $\leq$ 0.05 was considered statistically significant. Continuous variables were translated as the mean and standard deviation. After homogeneity of variance and normal distribution of errors had been confirmed, one-way analysis of variance was performed followed by Tukey's post-hoc test if showed significance. Student t-test was done for compared pairs. Two-way ANOVA test was done to detect effect of variables influencing mean value. Sample size (n =8) was large enough to detect large effect sizes for main effects and pair-wise comparisons, with the satisfactory level of power set at 80% and a 95% confidence level.

**Vertical Marginal fit measurement**

It was analyzed that Milled group recorded statistically non-significant higher vertical marginal gap mean value (39.38±7.57 µm) than 3D Printed group (33.23±7.98 µm) as proven with two - way ANOVA test (p = 0.0926 > 0. 05). Table (1) Figure (5).

**Table 1:** Comparison of total vertical marginal gap results (Mean values±SDs) as function of material group.

| Variable | | Vertical marginal gap | | |
|---|---|---|---|---|
| | | Mean±SD | 95% CI | |
| | | | Low | High |
| Material | 3D Printed | 33.23±7.98 | 27.7 | 38.76 |
| | Milled | 39.38±7.57 | 34.14 | 44.62 |
| Statistics | P value | 0.0926 ns | | |

ns; non-significant (p>0.05)

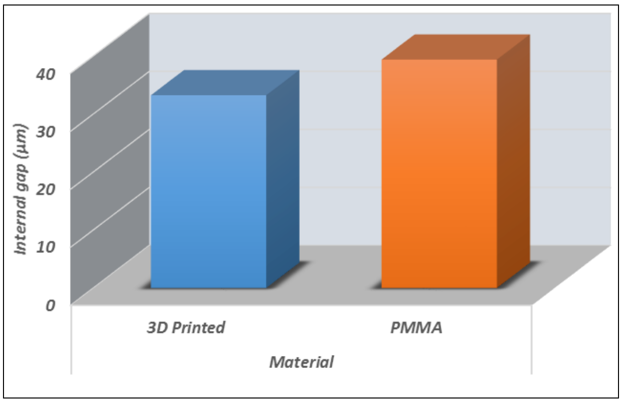


**Fig 5:** Column chart comparing total vertical marginal gap mean values as function of material group

**Internal fit measurement**

It was discovered that 3D Printed group was statistically non-significant greater internal gap mean value (71.07±8.09 µm) than Milled group (65.73±6.1 µm) as proven with two-way ANOVA test (p = 0.3279 >q0.05q). Table (2) Figure (6)

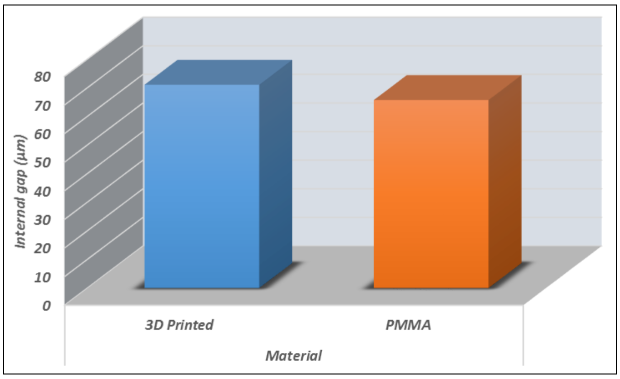


**Fig 6:** Column chart comparing total internal gap mean values as function of material group.

**Discussion**

Provisional bridges are seated on the typodont using holding jig to hold the bridge with standardized force.all the procedure were done without cementation to shut out the effect of cementation technique disparity.

Vertical marginal gap ranges from 10 to 160 µm to be clinically acceptable. Moldoven *et al.*, 2006 stated that 100 µm as good marginal misfit and 200 to 300 µm as acceptable misfit. Recently most investigators recommend conclusion stated by McLean and von Fraunhofer that to be clinically accepted maximum Vertical marginal gap would be 120 µm

The marginal and the internal discrepancy values of the digitalised FDP created using an IO scanner were, on average, lower than those measured by extra oral dental scanners used in laboratories, (Ozal Ç and Ulusoy M, 2021 ) (Dupagne *et al.*, 2023)

In the present study, it was discovered that the vertical marginal gap mean value recorded to the milled bridges was (39.38±7.57 µm) while the 3D printed group mean value was (33.23±7.98 µm) which is within clinically accepted range. The 3D printed provisional bridges showed greater marginal adaptation and fewer marginal inconsistency It's possible that the milling machine and end mill error have some sort of restriction on them. (Choi *et al.*, 2019) [4].

This conclusion is in agreement with several other research, Park *et al.* in 2016 indicated that the marginal discrepancy value of implant interim restorations in the 3D printed group was superior than that in the subtractive milling approach

(CAM). He linked positive or negative error to milling bur diameter that should be considered. Although the 3D printing process was extremely precise and quick to carry out, the end result was an equally moulded layer that had a uniform face.
Elfar *et al*. in 2018 [7] examined marginal adequecy of restoration that manufactured by subtractive milled wax patterns & 3D printed wax patterns. It was discovered that the subtractive group had the largest mean marginal gap value (42.18‡1.44), while the 3D printed group had the lowest value (40.33‡0.77). These findings were discovered through research. According to him, the utilisation of 3D printing produced the most exact marginal adaption due to the creation of a sequences of cross - sectional layers. After that, every layer is printed on above the other in order to build three-dimensional body with less of a marginal difference and enough compensation for the polymerization shrinkage.
Alharbi *et al*. in 2018 shown that the marginal gap of the additive bridgess are much inferior to the subtractive counterparts. It is possible that errors brought on by the tolerance of milling burs are to blame for the marginal fit of milled restorations being inferior. If this is the case, then any surface details that are lesser than milling bur diameter will be excesivly milled, which result in a improper fit of the bridges.
Opposing results obtained by Alshalan *et al*. in 2019, They found that whether the software design of CAD/CAM system was subtractive or additive it had an effect on the marginal adaption of the restoration. In addition, despite the numerous benefits of the additive technique, its marginal fit is inferior to that of the subtractive technique. Due to the shrinkage that occurred throughout the building process, post-curing, and the minimum thickness of the layers.
The retention depends mostly on the correct fit of provisional restoration, The evaluation of internal fit is one of the most clinical significant outcomes. Failure on internal fit (misfit) is ascribed to inadequate retention. Using silicon replica technique the internal fit was measured and magnification by stereomicroscope as it is a nondestructive, accurate, least distortion methodology for evaluation of internal fit that method was employed in agreement with Park *et al*, in 2015
Bhaskaran *et al*, in 2013 [3] found that the suitable internal gap ranges between 81 and 136 µm.
The provisional restoration was loaded with low viscosity light body silicone then was seated over the typodont by finger pressure till setting as suggested by Seok-Joon, and Jin-Hyun in 2016. After that, a heavy body silicon substance was filledn order to stabilize the lighter material, which made it simpler to manipulate and segment in the following steps. (Tamac *et al*., 2015) [18]
In the present investigation, 3D printed group had higher internal gap mean value (71.07±8.09 µm) than milled group mean value (65.73±6.1 µm), It is possible that this was caused by software mistakes that occurred during the process of translating the STL file into printable format (transferring it into layers), which resulted in an unsatisfactory presentation of the interior fit.
This result is in agreement with the findings of several other studies, including one conducted by Kim *et al*. in 2014 which the researchers compared the internal fit of a three-unit metal framework of fixed dental prostheses that was manufactered by subtractive and additive manufacturing techniques. They measured axial wall, and occlusal gaps. The results for the SM group were 87.20 plus 38.95 um and 138.34 plus 44.15 um. In contrast, the results of the AM group came in at 103.44 +39.99 um and 238.16+ 86.72 um, respectively. It was determined that this was due to a problem with the software.
According to Kang *et al*. in 2018 [10], the internal fit of restorations created by 3D printing was inferior to that which was produced using subtractive technology. Furthermore, the milling group demonstrated highly reproducible data in comparison to that which was shown by the 3D printing group. During creation of the 3D printed group, there may have been an occurrence of random mistake brought on by the light diffraction phenomenon. This is the theory for the lower reproducibility of the latter group. As a result of the development of layers, the surface of the 3D printing revealed an inaccurate representation. Also, the restorations that were made by 3D printing support originally eleminated by utilising diamond disc, the components meticulously finished and polished by a rubber bur. Despite this, there were still remnants of the support, which is one of the drawbacks associated with the 3D printing technology.
The results were in disagreement with Mai *et al* in 2020 [12], who observed that the milling group showed considerably higher internal gap in the occlusal region, than 3D printed polyjet group. Crowns made by the PolyJet group have a higher degree of precision in the occlusal region. This result may be related to a different underlying fabrication technique.

## Conclusion
**Within the qlimitationsq of the present study, the following points could be concluded**

- Provisional bridges fabricated by the two different methods of manufacturing (milling and 3D printing) The vertical marginal gap values were within the acceptable clinical range of one hundred twenty microns.
- The 3D printed provisional restorations presented equivalent marginal fit to that of the milled ones.

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**Conflicts of Interest:** The authors declare no conflict of interest.

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