



# Evaluation of the Marginal Fit of Single Crowns Fabricated from Digital and Conventional Impressions: An In Vitro Study

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## Abstract

**Background and objectives:** Intraoral scanners replace traditional dental impressions offering more comfort and precision. This research intends to evaluate the discrepancies in the marginal gaps of single crowns produced using traditional impression techniques versus digital intraoral scanners.

**Methods:** This in vitro study was conducted over a one-year period from Sep 2023 to Sep 2024. The clinical procedures were carried out at Shorsh dental center in Sulaymaniyah. Fifteen extracted premolars were prepared for crowns and mounted on a 3D-printed model. Using conventional polyvinyl siloxane and intra-oral scanning with Medit i700, fifteen monolithic zirconia crowns were produced for each technique utilizing computer-aided design/computer-aided manufacturing. Marginal adaptation was assessed using the replica technique with silicone materials. The marginal gap was calculated by determining the distance from the edge of the crown to the finish line margin at four different angles: buccal, palatal, mesial, and distal, then examined under a stereomicroscope, and analyzed with ImageJ software.

**Results:** The average mean of marginal gap in digital impression was (107 $\mu$ m) while in conventional impression was (173 $\mu$ m) and the difference was statistically significant with a p-value (0.033). When comparing each aspect separately there was a significant difference in the palatal, distal, and buccal aspects, p-value was (p = 0.004, p = 0.024 and p = 0.039) but not in the mesial aspect (p = 0.2).

**Conclusion:** The marginal gap was less in digital impression compared to conventional and the difference was statistically significant.

**Key words:** Conventional impression, Intraoral scanner, Marginal gap, Replica technique, Zirconia crown

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## Introduction

Dentistry is rapidly embracing digital technology, transforming how dental care is delivered and experienced. One of the ways is how intraoral scanners replace traditional dental impressions with digital ones, and making the conventional impressions questionable in their precision and comfort and the more time-consuming procedure, traditional impressions can take several minutes to set, while digital impressions using intraoral scanners capture a complete set of dental arches within a few minutes, eliminating the need for retakes and reducing patient discomfort.<sup>1,2</sup> The clinical efficacy of indirect restorations hinges on numerous factors, with marginal adaptation being a critical determinant. Achieving optimal marginal fit is essential to impede microleakage by oral pathogens, thereby preventing secondary caries and subsequent pulpal complications.<sup>3</sup> The accuracy of the marginal and internal fit is a fundamental factor for the durability and success of the dental prosthesis among them dental crown. Marginal gaps lead to the dissolution of luting material, facilitating biofilm formation and potentially leading to caries and periodontal disease.<sup>4-6</sup> The marginal fit is essentially characterized by a contiguous interface or a continuous transition devoid of gaps between the prepared tooth and the margin of the restoration.<sup>7</sup> It may be deemed acceptable if it escapes detection by the tip of a dental explorer, with a clinically approved range for marginal gaps falling between 100 to 150 $\mu$ m.<sup>8,9</sup> In the fabrication and restoration of prostheses, precision in impression-taking is of utmost importance. Traditional techniques using elastomeric impression materials and die-stone model production are widely regarded as the standard in fixed prosthesis construction.<sup>10,11</sup> Utilizing traditional impression materials can cause patient discomfort and pose challenges like material deformation and contamination. In

contrast, intraoral scanners offer direct scanning for digital impressions, allowing real-time correction, bite verification, and visualization of a three-dimensional 3D virtual cast on a monitor.<sup>12-15</sup> Digital impression-taking is less likely to cause deformation of the impression material, and the subsequent scanning and processing are relatively straightforward procedures.<sup>15</sup> Furthermore, in contrast to the traditional impression-taking techniques, this approach incurs lower costs and requires less time, thereby making it increasingly favorable.<sup>16,17</sup> Numerous studies have juxtaposed the conventional and digital methodologies. Nonetheless, findings have varied and shown inconsistency. While certain studies have indicated the superior accuracy of conventional techniques, others have highlighted better outcomes with digital methods.<sup>18,19</sup> This study was done to compare the accuracy of marginal gaps in single crowns fabricated using conventional impression techniques versus intra-oral digital impression techniques, to assess and quantify the differences in marginal gap accuracy between crowns produced through conventional and intra-oral impression methods, thereby determining which technique offers superior precision for prosthodontic restorations.

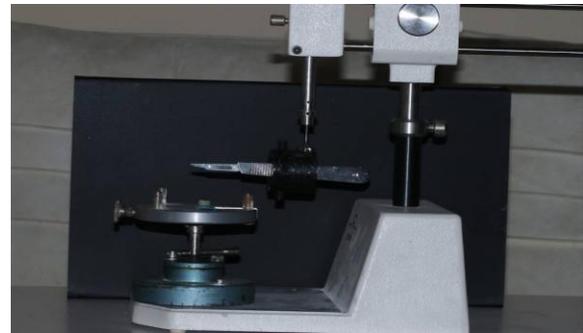
## Materials and methods

This in vitro study was conducted over a one-year period. The clinical procedures were carried out at Shorsh dental center in Sulaymaniyah from Sep 2023 to Sep 2024, while the laboratory work was completed in a dedicated dental laboratory, fifteen extracted upper first premolar teeth were collected and securely mounted on a plastic 3D-printed model, fixed in place with resin to prevent movement. The model was then stabilized on a small table. The teeth were prepared for full crowns using a protocol that included 1.0 mm axial wall reduction (facial, lingual, and proximal) and 1.5 mm from

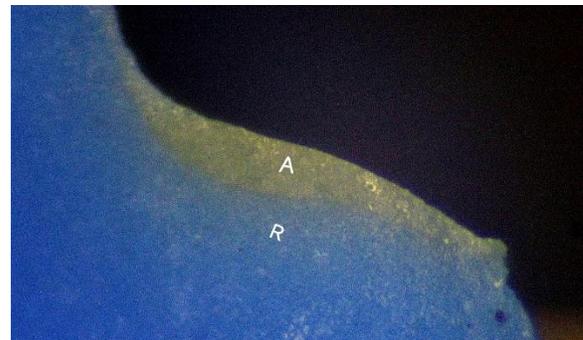


occlusal surface. Chamfer finishing line created for all the teeth by using high speed hand piece (Jimmy J5, China) and using diamond round end tapered fissure bur from (Jota-Switzerland no, 852 FFG 018, 852 FFG 016). Two impression techniques were employed for each model: conventional and intra-oral scanning (IOS) using the Medit i700 for the conventional method, impressions were taken as a one-step technique using polyvinyl siloxane VPS impression material (A-SILICONE PROCLINIC, ITALY) regular set heavy body and fast set light body (VPS IMPRESSION PROCLINIC, ITALY), then a stone cast model was fabricated from the impression with gypsum type IV stone from GC (GC FUJIROCK, Japan). Then fifteen monolithic zirconia crowns were designed and fabricated using computer-aided design/computer aided manufacturing (CAD/CAM) technology. For the IOS method, after scanning the abutments the scans were converted to standard tessellation language (STL) files, and fifteen monolithic zirconia crowns were similarly designed and constructed using CAD/CAM technology. Both procedures were conducted by the same operator, maintaining identical parameters for crown design, cement gap 0.04 mm, and material thickness. The same milling machine was used for both processes, resulting in a total of thirty monolithic zirconia crowns (fifteen from conventional impressions and fifteen from IOS). To determine the marginal gap, the replica technique was employed. A low viscosity silicone light body impression material (VIRTUAL LIGHT BODY FAST SET, Ivoclar Vivadent, Switzerland) was used as a cement analog and placed inside the crown, which was then fitted over the abutment with constant finger pressure applied until fully set, following the manufacturer's instructions. Subsequently, the crown, along with its cement analog, was removed. A

heavy body silicone gun type (VIRTUAL HEAVY BODY FAST SET, Ivoclar Vivadent, Switzerland) was then injected into the removed crown and over the silicone cement analog. After the silicone material fully set, it was removed as a single unit, comprising both the cement analog and the injected silicone abutment replica. This unit was then sectioned mesiodistally and buccopalatally at the center using a No. 15 blade and scalpel attached to a dental surveyor for precision and repeatability, as illustrated in Figure (1). Each section, consisting of two-color coded silicon materials—a light brown cement analog and a blue abutment replica (injected silicon)—was examined under a stereomicroscope at 40x magnification Figure (2).



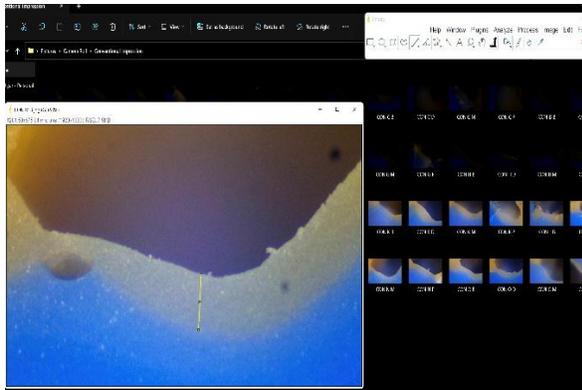
**Figure (1):** A No. 15 blade and scalpel attached to a dental surveyor for cutting the replica silicon placed over the mounting table.



**Figure (2):** A section of the vinyl polysiloxane (VPS) under stereomicroscope, yellow area cement analog (A), blue area abutment replica or injected silicon (R)



Consistent-distance photographs were taken and imported into ImageJ software (version 1.8.0) for analysis. The marginal gap was measured by determining the distance from the crown margin to the edge of the finish line at four different angles: buccal, palatal, mesial, and distal. Prior to measuring the marginal gap distance, the calibration unit within the ImageJ software was adjusted. This involved placing a ruler under the microscope, set to the same parameters as the silicon examination, capturing a 1mm distance as a photo, and importing it into ImageJ. This 1mm distance was then set as 1000  $\mu\text{m}$  in the software, ensuring accurate measurements. Using this calibration, distances were measured between two points on each section Figure (3).



**Figure (3):** During measurement with ImageJ software, a straight line was drawn from the top to bottom of the cement replica to determine the distance.

The ethical committee of Sulaimani University approved the study. (Issue No.: 22/111, Date: 9/6/2022). All statistical analyses were conducted using SPSS version 26. The data were summarized with descriptive statistics, presented as means and standard deviations. The Shapiro–Wilk test assessed the normality of the data

distribution. For normally distributed data, an independent t-test was employed, while the Mann-Whitney test was utilized for data that did not conform to a normal distribution. A p-value of  $\leq 0.05$  was considered to indicate statistical significance.

## Result

The study compared the mean marginal gaps at the buccal, palatal, distal, and mesial aspects between digital and conventional impressions. The mean marginal gap for buccal in digital impression was (95.3 $\mu\text{m}$ ) which is lesser compared to conventional which was (129.7 $\mu\text{m}$ ) and the difference was statistically significance with a p-value of (0.039). As for palatal aspect the mean marginal gap in digital impression was (114 $\mu\text{m}$ ) which is lesser compared to conventional which was (231 $\mu\text{m}$ ) and the difference was statistically significance with a p-value of (0.004). Again, for distal aspect the mean marginal gap in digital impression was (112 $\mu\text{m}$ ) which is lesser compared to conventional which was (194 $\mu\text{m}$ ) and the difference was statistically significance with a p-value of (0.024). However, in the mesial aspect the mean marginal gap in digital impression was (106.9 $\mu\text{m}$ ) although it is lesser compared to conventional which was (140 $\mu\text{m}$ ) but the difference was not statistically significance the p-value was (0.2) which is more than (0.05) as illustrated in Table (1). The table below shows the values for marginal gap in both digital and conventional impressions in all aspects, with standard deviation, standard error, type of test used and the p-value for each.



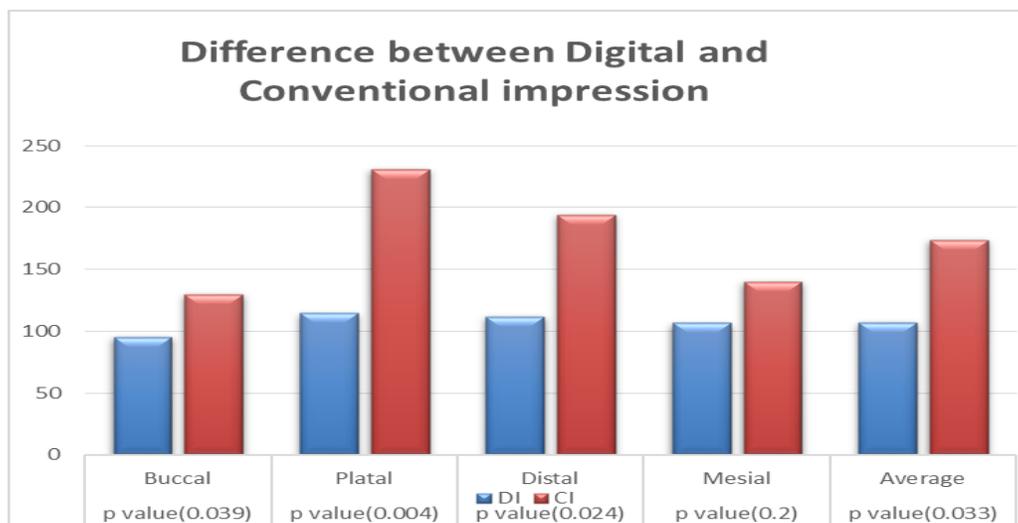


**Table (1):** Data shows the mean of marginal gap measured in ( $\mu\text{m}$ ) at buccal, palatal, distal and mesial aspects, with their p-values. DI: digital impression, CI: conventional impression

	Group	N	Mean in ( $\mu\text{m}$ )	Std. Deviation	St. Error Mean	Type of test used	p-value
Buccal	DI	15	95.3083	40.39965	10.43115	Independent t test	0.039
	CI	15	129.7973	46.51329	12.00968		
Palatal	DI	15	114.6147	59.59385	15.38707	Mann-Whitney test	0.004
	CI	15	231.0303	218.31047	56.36752		
Distal	DI	15	112.0506	45.50652	11.74973	Mann-Whitney test	0.024
	CI	15	194.4354	146.27131	37.76709		
Mesial	DI	15	106.9144	41.65882	10.75626	Mann-Whitney test	0.2
	CI	15	140.1859	75.34392	19.45372		
Average	DI	15	107.2228	33.52639	8.65648	Mann-Whitney test	0.033
	CI	15	173.8632	109.73807	28.33425		

Overall, the average mean of marginal gap in digital impression was ( $107\mu\text{m}$ ) which is lesser compared to conventional impression which is ( $173\mu\text{m}$ ) and the difference was statistically significance with a p-value

(0.033). the figure below is a bar chart comparing the marginal gap in all aspects between the digital and conventional impression, Figure (4).



**Figure (4):** Mean of marginal gap in ( $\mu\text{m}$ ) between digital and conventional impression at buccal, palatal, distal and mesial aspects, with their p values.

### Discussion

The purpose of this study is to compare the marginal gaps of single crowns produced using traditional impression techniques and digital intraoral scanners (IOS). The null hypothesis was rejected, as the results revealed significant differences in most aspects ( $p < 0.05$ ), including the buccal,

palatal, and distal regions. However, for the mesial aspect, although the digital method resulted in a smaller marginal gap, the difference was not statistically significant. Both groups demonstrated marginal gaps within the clinically acceptable range. Currently, there is no consensus on the maximum clinically acceptable marginal gap





width, with reported values ranging from 50 to 200 $\mu$ m, highlighting the absence of an objectively defined threshold.<sup>20,21</sup> In this study, the replica technique was utilized to calculate the marginal fit, an indirect method involving the use of heavy and light body silicone materials to create a replica of the tooth and the gap. This method was selected based on a previous study that compared the accuracy of various techniques for measuring marginal gaps, which found no significant differences between the methods. The latter compared five methods including replica technique for assessing marginal and internal fit in fixed prostheses.<sup>18</sup> In clinical experiments, the quality of restoration fitting can be evaluated through tactile assessment, intraoral radiographs, and the replica technique.<sup>21-23</sup> The replica method entails making a silicone mold of the gap between the dental prosthesis, for instance crown and the teeth and then measuring it with a microscope. This approach accurately predicts the thickness of the cement, regardless of its position.<sup>24-26</sup> A laboratory study assessed the internal fit of lithium disilicate prosthesis using micro-CT scanning, indicated that CAD/CAM crowns manufactured with the Lava digital impression system exhibited a superior internal adaptation compared to those constructed using the traditional impression technique. The latter is in agreement with the present study's findings.<sup>27</sup> Numerous in vitro studies support the findings of this research, showing that restorations made using intraoral impressions achieve a marginal fit of less than 100 $\mu$ m. Some studies have found that digital impression systems offer accuracy comparable to traditional impression methods for creating fixed restorations.<sup>28,29</sup> Furthermore, according to a study by Syrek et al., both impression methods achieved a fit that is clinically satisfactory.<sup>30</sup> However, for the single crowns that are constructed from a digital

impression demonstrated a superior adaptation. Simultaneously, Euan et al. and Ng et al. found that digital intraoral impressions resulted in better marginal fit.<sup>31,32</sup> However, it's important to recognize that scanning preparations on a typodont without oral fluids like saliva and blood does not reflect the difficulties of scanning in a real intraoral environment. However, thoroughly executed in vitro experiments can still provide significant information regarding precision assessments. Moreover, a direct evaluation of precision across various digital impression technologies could not be performed due to the limited number of existing studies.<sup>33</sup>

## Conclusion

The research findings reveal significant differences between digital and traditional impressions in three of the four areas measured. However, digital impressions demonstrated a smaller marginal gap compared to traditional methods. The considerable variation in average values supports the conclusion that digital impressions provide advantages in these specific areas.

## Conflict of Interest

The authors have disclosed that they have no conflicts of interest concerning the publication of this work.

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