The Effect of Different Pouring Interval of Conventional Impression on the Marginal Accuracy of Full Contour Zirconia Crowns in Comparison with Digital Impression (An in vitro study)

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ABSTRACT
Background: The success and maintenance of indirect dental restorations is closely related to the marginal accuracy, which is affected by many factors like preparation design, using of different fabrication techniques, and the time of taking final impression and pouring it. The purpose of this in vitro study was to evaluate the effect of different pouring time of conventional impression on the vertical marginal gap of full contour zirconia crowns in comparison with digital impression technique.

Materials and Methods: Forty sound recently extracted human permanent maxillary first premolar teeth of comparable size and shape were collected. Standardized preparation of all teeth samples were carried out to receive full contour zirconia crown restoration with deep chamfer finishing line all around the tooth with (1mm) depth, axial length (4mm) and convergence angle (6 degree). The specimens separated into two groups; Group A; eight specimens were scanned digitally by using Omnicam scanner; Group B; conventional impressions were taken for the remaining thirty two specimens and further subdivided to four groups according to the time of impression pouring; Group B1: PVS were poured after 30 minutes; Group B2: PVS were poured after 24 hours; Group B3: PVS were poured after 7 days; Group B4; PVS were poured after 14 days. Marginal discrepancy was measured at four points at each tooth surface. Sixteen points per tooth were measured using digital microscope at (180X) magnification. One-way ANOVA test and LSD test were carried out to see if there was any significant difference among the means of the conventional impression groups. Independent samples t-test was carried out to examine if there is any significant difference between digital and conventional impression technique.

Results: Group B2 had the least mean of marginal gap with statistically significant difference when compared to Group B1 and statistically highly significant difference when compared to group B3 and B4. There was a statistically highly significant difference in the vertical marginal gap between digital impression technique and conventional impression.

Conclusions: The pouring of conventional impression after 24 hours provides better marginal fit than other pouring time. The digital impression provides better marginal fit than conventional impression.

Key words: marginal accuracy, pouring time, conventional impression, digital impression, (J Bagh Coll Dentistry 2018; 30(1): 17-22)

INTRODUCTION
The first step required to fabricate well-fitting indirect restorations is precise dental impressions with high degree of dimensional stability and fine details reproducibility. The accuracy of the impression material reflects its ability to be dimensionally stable over time, therefore the amount of time elapses between securing the impression and casting in gypsum greatly affect the quality of restoration (1). Although the delay of pouring period allows both the release of volatile substances and elastic recovery of the material, it should be limited; otherwise distortions of the impression will occur. PVS impression materials are the most dimensionally stable and can be poured hours, days or even weeks after impression taking. However, their dimensional stability also depends on the exact time of pouring stone dies (2).

The most important factor that determines the survival and success of fixed prosthesis is the marginal fitness. Marginal misfit or large gap negatively affects the prosthesis, which may lead to microleakage with plaque accumulation thus increasing the risk of recurrent caries and periodontal inflammation (3, 4).

Marginal gap does not only depend on the design of the tooth preparation, finishing line type, type of cementation medium only but also on the proper impression (5). The dimensional accuracy of the elastomeric impression materials based on various factors such as the delay or second pour, humidity, temperature, and impression techniques (6). The introduction of CAD/CAM systems in 1980s to the dental field resolved a wide range of these limitations found in the conventional impression techniques since they provide speed, property of storing and transferring captured images indefinitely with no distortion (7). Studies have been reported the average marginal discrepancies for CAD/CAM restoration range from 24-110 μm (8).

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MATERIALS AND METHODS

Samples preparation
Each tooth sample was prepared to receive full contour zirconia crown with the following preparation features; a flat occlusal surface with 4mm axial length, deep chamfer finishing line 2 mm coronal to the cemento-enamel junction all around the tooth with 1mm depth, and convergence angle of 6° (9,10) as shown in figure 1.

Conventional impression procedure
Eight impression trays especially designed for this study were made with three pins in the base of the special tray to engage the three holes on the acrylic base of each specimen, these holes serve as a guide and stopper for the special tray during impression procedure. The top surface of the special tray has a metal rod attached to the suspending arm of the dental surveyor during impression taking procedure to ensure a standardized path of insertion and removal of the special tray during impression taking.

One step impression technique was done for four subgroups (B1, B2, B3, and B4) by using heavy and light viscosity polyvinyl siloxane impression materials. The heavy viscosity impression material (Express™ XT Penta™ Heavy) was loaded in the special tray, while light viscosity Vinyl polysiloxane impression material (Express™ XT) was injected all around the prepared tooth. The tray was then seated over the specimen until the three guided pins completely engaged the holes in the acrylic base of the specimen and the tray kept under a defined load of 500g until the complete set of impression material (11) (Fig. 2). After about 3.5 minutes, the two impression materials were set (according to the manufacturer’s instructions) and removed from the specimen.

Pouring procedure
The impression was poured with type IV gypsum (die stone) which was mixed with distilled water with a powder/water ratio of (100g/25mL). The amount of powder was measured using a digital scale, while the amount of water was measured using a graduated glass tube, and mixed for 60 seconds. The impression was poured using a vibrator. The stone die was separated from the impression after 45 minutes according to the manufacturer’s instructions.

The same pouring procedure was repeated for subgroups B1, B2, B3, and B4 after the storage of impressions at different times (30 minutes, 24 hours, 7 days, and 14 days respectively) in an incubator at room temperature (25°C) according to the manufacturer’s instructions.

Fabrication of crowns
Scanning the teeth for group A was taken using omnicam scanner (Sirona Dental Systems, Bensheim, Germany). The scanning was carried out by moving the camera head over the teeth in a single flowing motion from buccal, occlusal and palatal surfaces in continuous motion, and then the data was generated successively into a 3D model on the monitor with natural color (Fig. 3). The scanning of the dies for subgroups B1, B2, B3, and B4 was carried out using inEosX5 Blue scanner (Sirona Dental Systems, Bensheim, Germany) as shown in figure 4.
The designing of the crown in “MODEL” phase was the next step. The margin of the preparation was automatically detected by the software system. The undercut was checked and the path of insertion was determined. Crown milling parameters were determined according to Sirona instructions as follows: die and tooth spacer (80μm), marginal thickness (150μm), minimum radial wall thickness (500μm), minimum occlusal thickness (700μm), and margin thickness (150μm).

Milling of InCoris TZI C disk using Sirona CEREC inLab MCX5. After the milling was completed, zirconia crowns were chalky in color and milled approximately 20-25% greater in size; therefore, they needed dense sintering process in inFire HTC Speed oven (Sirona, Germany) at 1540º C for two hours.

**Measurement of marginal gap**

The vertical marginal gap was measured at four indentations on the margin area at the midpoint of buccal, mesial, palatal and distal surfaces of the tooth by using a digital microscope (12, 13). In order to maintain a constant seating pressure between the crown and the tooth during measurement of MG, the specimen attached to specimen holding device which specially designed to maintain constant pressure of 50N nearly equal to 5Kg and placed under the digital microscope (14).

The digital microscope was used at a magnification of 180X that was fixed in a manner that maintains its lens perpendicular to the crown/tooth margin during measurement procedure and connected via the computer. The digital images were captured and the measurements were done using IMAGE J software which calculated the values in pixels (15) (Fig 5). For the calibration of the software, a photograph of a(1mm) increment taken at the same focal length and input into IMAGE J by the option of set scale, which converted all the calculated reading from pixels to μm (16).

**Statistical analyses**

Data were collected and analyzed using SPSS (statistical package of social science) software version 15 for windows 8.1 (Chicago, USA).

The following statistics were used:
A- Descriptive statistic: including mean, standard deviation, statistical tables and graphical presentation by bar charts.
B- Inferential statistics
  1- One-way ANOVA (analysis of variance) test was carried out to test difference among conventional impression groups.
  2- LSD (least significant difference) test was used to examine the source of difference.
  3- Independent samples t-test was carried out to examine the difference between digital and conventional impression technique.
RESULTS
Total of 640 measurements of vertical marginal gap from five groups were recorded, with 16 measurements for each crown.

Table 1 showed that the highest mean of vertical marginal gap was recorded in group B4 (90.971±5.470) (pouring polyvinyl siloxane impression after 14 days) while the lowest mean marginal gap was recorded in group A (40.635±2.447) (digital impression using Omnicam scanner) and this clearly explained in figure 6.

Table 2 showed that there was a statistically highly significant difference in the vertical marginal gap among the four subgroups (B1, B2, B3, and B4). Table 3 showed that there was a statistically significant differences in the marginal gap mean values between subgroup B1 and subgroup B2, and a highly statistically significant differences in the marginal gap mean values between subgroups B1 and B3, B1 and B4, B2 and B3, B2 and B4, and between subgroups B3 and B4.

Table 1: Descriptive statistics of vertical marginal gap for the five groups in (μm).

<table>
<thead>
<tr>
<th>Group</th>
<th>No.</th>
<th>Mean</th>
<th>S.D.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A- Omnicam scanner</td>
<td>8</td>
<td>40.635</td>
<td>±2.447</td>
<td>37.961</td>
<td>44.673</td>
</tr>
<tr>
<td>B1- pouring conventional impression after 30 minutes</td>
<td>8</td>
<td>52.775</td>
<td>±2.760</td>
<td>48.036</td>
<td>55.579</td>
</tr>
<tr>
<td>B2- pouring conventional impression after 24 hours</td>
<td>8</td>
<td>48.867</td>
<td>±3.306</td>
<td>41.736</td>
<td>52.059</td>
</tr>
<tr>
<td>B3- pouring conventional impression after 7 days</td>
<td>8</td>
<td>71.676</td>
<td>±4.620</td>
<td>65.436</td>
<td>76.769</td>
</tr>
<tr>
<td>B4- pouring conventional impression after 14 days</td>
<td>8</td>
<td>90.971</td>
<td>±5.470</td>
<td>83.893</td>
<td>97.525</td>
</tr>
</tbody>
</table>

Table 4 showed that there was a statistically highly significant difference in the vertical marginal gap between digital and conventional impression.

Table 2: One-way ANOVA test among the four conventional impression subgroups.

<table>
<thead>
<tr>
<th>ANOVA</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean square</th>
<th>F-test</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>8993.429</td>
<td>3</td>
<td>2997.810</td>
<td>171.717</td>
<td>0.000 (HS)</td>
</tr>
<tr>
<td>Within Groups</td>
<td>488.821</td>
<td>28</td>
<td>17.458</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9482.250</td>
<td>31</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Significant at P≤ 0.05

Table 3: LSD test for comparison of significance between subgroups.

<table>
<thead>
<tr>
<th></th>
<th>Mean difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>-3.908</td>
<td>0.042 (S)</td>
</tr>
<tr>
<td>B2</td>
<td>-18.901</td>
<td>0.000 (HS)</td>
</tr>
<tr>
<td>B3</td>
<td>-38.196</td>
<td>0.000(HS)</td>
</tr>
<tr>
<td>B4</td>
<td>-42.104</td>
<td>0.000 (HS)</td>
</tr>
<tr>
<td>B5</td>
<td>-19.295</td>
<td>0.000 (HS)</td>
</tr>
</tbody>
</table>

Table 4: Independent samples t-test between group A and B2.

<table>
<thead>
<tr>
<th></th>
<th>t-test for equality of means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t</td>
</tr>
<tr>
<td>Equal variance assumed</td>
<td>-5.660</td>
</tr>
<tr>
<td>Equal variance not assumed</td>
<td>-5.660</td>
</tr>
</tbody>
</table>

DISCUSSION
The results of this study revealed that the pouring of the conventional impression after 24 hours provided less marginal gap than other times of pouring of conventional impression. This may be due to shrinkage of the addition silicone towards the tray which produced larger die, therefore provided better seating of the crown with less marginal gap than the marginal gap of crowns fabricated from pouring the impression after 30 min. This explanation comes in agreement with Kumar et al (17) who concluded that addition silicones after 24 hours contracted towards the tray and gave a die slightly bigger in diameter than the standard master die.

The gap of the zirconia crowns that fabricated after 7 and 14 days of impression pouring were increased, this might be due to delay shrinkage of impression away from the tray which was lead to smaller die and result in an increase in the gap between the crown and the tooth. This delay in dimensional changed of addition silicone is
explained by Fano et al. (18) who concluded that the instability of PVS due to the polymerization reaction is complete after hours, but the contribution of the constituent evaporation can have a significant long-term role. This dimensional change of the impression over time is in agree with Garrofé et al. (19) who study the accuracy of three types of addition silicone over time up to 14 days and found significant differences for time-material interaction. The dimensional changes with delay in pouring occurred in addition silicone may result, among other reasons, from incomplete elastic recovery due to viscoelastic behavior of the material, relaxation of stresses, or from residual polymerization in which new covalent bonds are formed within the material molecules reducing the volume occupied by them. Thus loss of accuracy will occur over time (18,20).

The results of this study revealed that the digital impression technique provided less marginal gap than the conventional impression. The difference in the marginal gap between two groups might be due to the steps that required with conventional impression procedure like tray selection, disinfection, casting stone model, manual die trimming, and other steps needed for articulation are eliminated (21). Furthermore, an enhanced intraoral optical camera might have the ability to recording fine details which in turn lead to a better adaptation of crown (22). This result comes in agree with previous studies (9,23) who concluded that crown restorations fabricated using chairside intraoral scanner showed better marginal adaptation than those made from dental casts scanning. However, this finding is not in agreement with (23) who concluded that accuracy of the digital impression is similar to that of the conventional impression. Such disagreement could be due to the difference in the methodology used.

REFERENCES


The Effect of...