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, **(J Bagh Coll Dentistry 2017; 29(4):1-6)**

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 samples 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 (Fig.1).

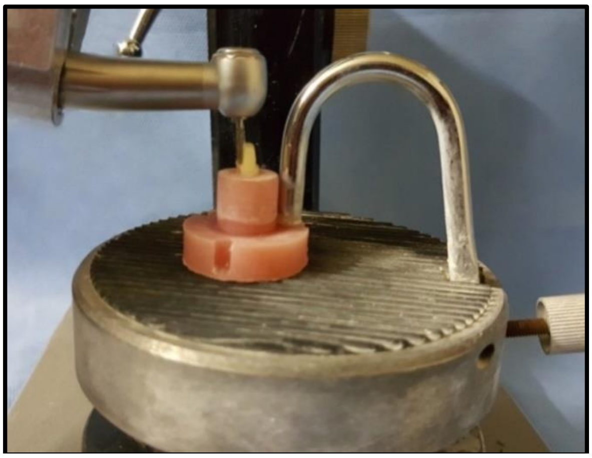

Figure 1: Tooth preparation using a modified dental surveyor.

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) as shown in (Fig.2). After about 3.5 minutes, the two impression materials were set (according to the manufacturer's instructions) and removed from the specimen.

Figure2: Impression taking with the dental surveyor.

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 as shown in (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 fig.3

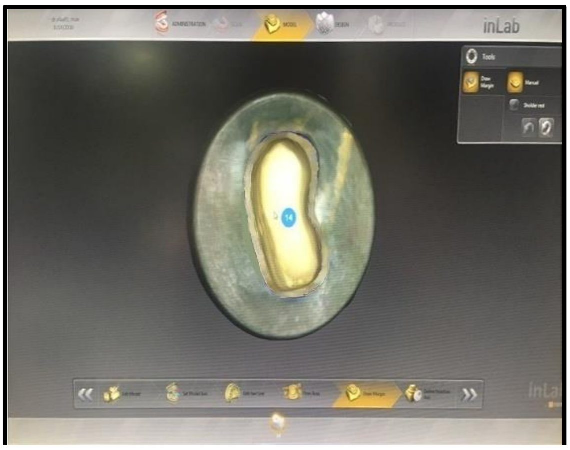

Figure 3: Scanning of teeth using omnicam scanner

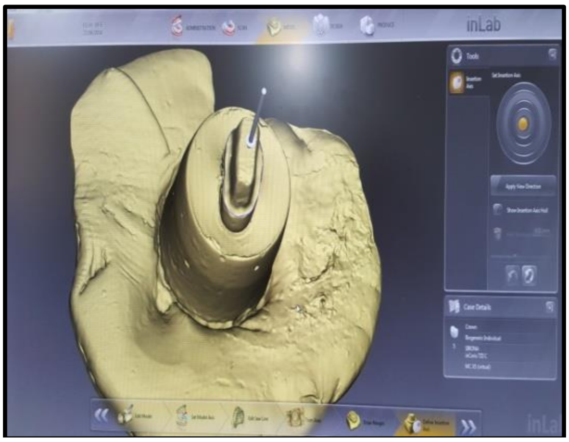

Figure 4: Scanning of die stone using inEos X5 Blue scanner

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].

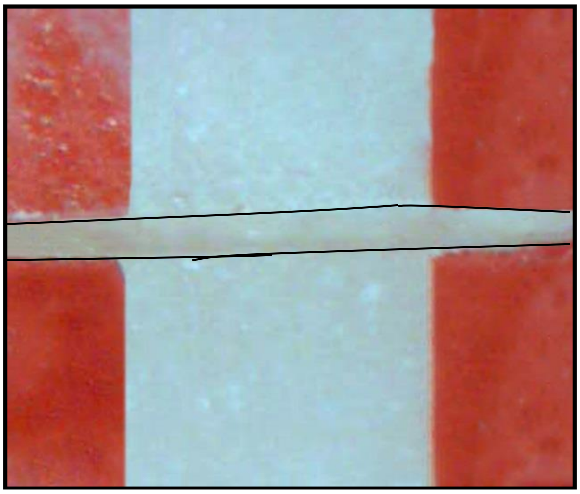

Figure 5: Digital image captured by digital microscope.

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 see if there was any significant difference among the means of the conventional impression groups.

2-LSD (least significant difference) test was carried out to examine the source of difference.

3- Independent samples t-test was carried out to examine if there is any significant 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: Descriptive statistics of vertical marginal gap for the five groups in (µm)

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

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 (Fig.6).

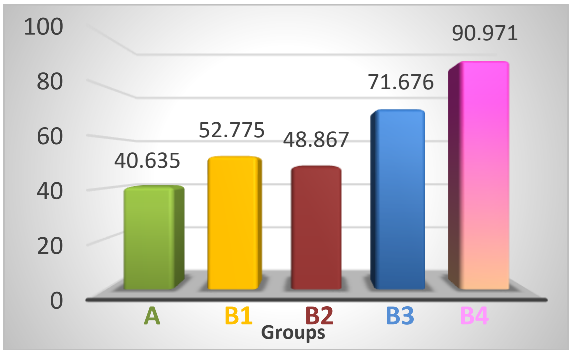

Figure 6: the mean values of the vertical marginal gap of all groups

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

ANOVA	Sum of Squares	df	Mean square	F-test	p-value
Between Groups	8,993.429	3	2,997.810	171.717	0.000 (HS)
Within Groups	488.821	28	17.458		
Total	9,482.250	31			

Significant at P≤ 0.05

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: LSD test for comparison of significance between subgroups B1, B2, B3, and B4.

		Mean difference	p-value
B1	B2	3.90825	0.042 (S)
	B3	-18.90113	0.000 (HS)
	B4	-38.19563	0.000(HS)
B2	B3	-22.80938	0.000 (HS)
	B4	-42.10388	0.000 (HS)
B3	B4	-19.29450	0.000 (HS)

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 (subgroup B1 and subgroup B3), (subgroup B1 and subgroup B4), (subgroup B2 and subgroup B3), (subgroup B2 and subgroup B4), (subgroup B3 and subgroup B4).

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

		t-test for equality of means		
			df	Sig. (2-tailed)
Value	Equal variance assumed	-5.660	14	0.000
	Equal variance not assumed	-5.660	12.901	0.000

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

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, 19, 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 Bindl and Mormann; Khdeir and Ibraheem **[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

1. Neethu, L. &Gilsa, K. V. Comparative evaluation of dimensional stability of three different elastomeric impression materials – An In vitro study. JDMS, 14(9), 89-93, 2015.
2. Eduardo, B. F., Leonardo, F.C. &Ana, R.B. Effect of storage period on the accuracy of elastomeric impressions. J Appl. Oral Sci, 15*(3)*, 195-8, 2007.
3. Contrepois, M., Soenen, A., Bartala, M. &Laviole, O. Marginal adaptation of ceramic crowns: A systematic review. J Prosthet Dent, 110, 447-54, 2013.
4. Hamza, T.A., Ezzat, H.A, El-Hossary, M.M., Katamish, H.A., Shokry, T.E. &Rosenstiel, S.F. Accuracy of ceramic restorations made with two CAD/CAM systems. J Prosthet,109, 83-7, 2013.
5. Anadioti, E. Internal and marginal fit of pressed and cad lithium disilicate crowns made from digital and conventional impressions. Master thesis, Department of Oral Science, University of Iowa. 2013.
6. Pant, R., Juszczyk, A. S., Clark, R. K. F. & Radford, D. R. Long-term dimensional stability and reproduction of surface detail of four polyvinyl siloxane duplicating materials. J Dent,36(6), 456-61, 2008.
7. Kim, S.Y., Kim, M.J, Han, J.S, Yeo, I.S, Lim, Y.J. &Kwon, H.B. Accuracy of dies captured by an intraoral digital impression system using parallel confocal imaging. Int J Prosthodont, 26(2), 161-3, 2013.
8. Karatasli, O., Kursoglu, P., Capa, N.&Kazazaoglu, E. Comparison of the marginal fit of different coping materials and designs produced by computer aided manufacturing systems. Dent Mater J, 30(1), 97-102, 2011.
9. Bindl, A.&Mormann, W.H. Marginal and internal fit of all-ceramic CAD/CAM crown-copings on chamfer preparations. J Oral Rehabil, 32, 441-7, 2005.
10. Al-Joboury, A.I. An evaluation of the influence of different finishing lines on the fracture strength of full contour zirconia CAD/CAM and heat press all-ceramic crowns. A master thesis, College of Dentistry, University of Baghdad. 2013.
11. Duseja, S., Shah, R.J., Shah, D.S. & Duseja, SH. Dimensional measurement accuracy of recent polyether and addition silicone monophase impression materials after immersion in various disinfectants: An in vitro study. International J. of Healthcare and Biomedical Research,2(4), 87-97, 2014.
12. Holmes, J.R., Bayne, S.C., Holland, G.A. &Sulik, W.D. Considerations in measurement of marginal fit. J Prosthet Dent, 62(2), 405-8, 1989.
13. Holden, J., Goldstein, G., Hittelman, E. & Clark, E. Comparison of the marginal fit of pressable ceramic to metal ceramic restorations. J Prosthodont, 18, 645-8, 2009.
14. Dittmer, M.P., Borchers, L., Stiesch, M.& Kohorst, P. Stresses and distortions within zirconia-fixed dental prostheses due to the veneering process. Acta Biomater, 5, 3231-9, 2009.
15. Tan, P.L., Gratton, D.G., Diaz-arnold, A.M. &Homles, D.C. An in vitro comparison of vertical marginal gaps of CAD/CAM titanium and conventional cast restorations. J Prosthodont, 17(5), 378-83, 2008.
16. Romoe, E., Iorio, M., Syorelli, S., Camandona, M. &Abati, S. Marginal adaptation of full coverage CAD/CAM restorations: In vitro study using a non-destructive method. Minerva Stomatol, 58(3), 61-72, 2009.
17. Kumar, D., Madihalli, A.U., Reddy, K.K., Rastogi, N. & Pradeep, N.T. Elastomeric impression materials: a comparison of accuracy of multiple pours. J of contemporary dental practice, 12(4), 272-8, 2011.
18. Fano, V., Gennari, P.U. &Ortalli, I. Dimensional stability of silicone-based impression materials.Dent Mater J,8,105-9, 1992.
19. Garrofέ, A.B., Ferrari, B.A., Picca, M. & Kaplan, A.E. Linear dimensional stability of

elastomeric impression materials over time. Acta Odontol Latinoam, 24(3), 289-94, 2011.
20. Mehta, R., Dahiya, A., Mahesh, G., Kumar, A., Wadhwa, S., Duggal, N. &Pande, S. Influence of Delayed Pours of Addition Silicone Impressions on the Dimensional Accuracy of Casts. JOHCD, 8(3), 148-53, 2014.
21. Burgess, J.O., Lawson, N.C.&Robles, A. Digital Impression System Considerations. J Inside Dent, 11(9), 2015.
22. Beuer, F., Schweiger, J. & Edelhoff, D. Digital dentistry: an overview of recent developments for CAD/CAM generated restorations. Br Dent J, 204 (9), 505-11, 2008.
23. Khdeir, R.M.&Ibraheem, A.F. The marginal fitness of CAD/CAM all ceramic crowns constructed by two types of direct digitization techniques (an in vitro study). JBCD, 28(2), 30-3, 2016.
24. Ender, A. &Mehl, A. Full arch scans: conventional versus digital impressions—an in-vitro study. Int J Comput Dent, 14(1), 11-21, 2011.

الخلاصة

يرتبط نجاح وديمومة التركيبات السنية غير المباشرة ارتباطا وثيقا بالدقة الهامشية, والذي يتأثر بعدة عوامل مثل تصميم التحضير, استخدام طرق تصنيع مختلفة, ووقت اخذ الطبعة النهائية وصبها. لذلك فأن الهدف من هذه الدراسة المختبرية هو تقييم تأثير اختلاف اوقات صب الطبعات التقليدية على التطابق الهامشي العمودي للتيجان الزركونية كاملة الشكل بالمقارنة مع تقنية الطبعة الرقمية.
تم تجميع (40)نموذج من الاسنان الضواحك الاولى العليا المقلوعة لغرض العلاج التقويمي ذات حجم وشكل متقارب.تم تنفيذ تحضيرقياسي لكل عينات الاسنان لتلقي التيجان الزركونية كاملة الشكل مع حافة لثوية نوع الشذف العميق بعمق (1ملم),وطول محوري (4 ملم), وزاوية ميلان (6 درجات). تم فصل العينات الى مجموعتين: المجموعة(أ)تحتوي على 8 عينات تم تصويرها بواسطة كاميرا (اومنيكام), المجموعة (ب) اخذت الطبعات التقليدية ل 32 عينة متبقية وتنقسم أيضا على أربع مجموعات وفقا لوقت صب الطبعات (ب1) تم صب طبعات البولي فينيل سيلكون بعد 30 دقيقة , (ب2) تم صب طبعات البولي فينيل سيلكون بعد 24 ساعة , (ب3) تم صب طبعات البولي فينيل سيلكون بعد 7ايام , (ب4) تم صب طبعات البولي فينيل سيلكون بعد 14 يوم.
وقد تم قياس التباين الهامشي في أربع نقاط على كل سطح من اسطح الأسنان اي قياس16 نقطة لكل سنبواسطة المجهر الرقمي بتكبير(180مرة) .
نتائج هذه الدراسة اظهرت ان اقل فجوة هامشية سجلت للمجموعة (أ) (40,635 ±2,447مايكرون) بينما اكبر فجوة هامشية سجلت للمجموعة(ب4)(90,971±5,470مايكرون). بالنسبة لوقت صب الطبعات اختبارANOVA احادي الاتجاه اظهراختلافا احصائيا هاما للغاية بين المجموعاتونتائج ال LSD اظهرت ان المجموعة (ب2) ذو اقل فجوة هامشية (48,867±3,306مايكرون)يختلف اختلافا احصائيا هاما بالمقارنة مع المجموعة(ب1) واختلافا احصائيا هاما للغاية بالمقارنة مع المجاميع (ب3) و(ب4). كما اظهر اختبار (Independent samples t-test)ان هناك اختلافا احصائيا هاما للغاية في الفجوة الهامشية العمودية بين تقنية الطبعة الرقمية والطبعة التقليدية.
وكأستنتاج فأن صب الطبعات التقليدية بعد 24 ساعة توفر دقة هامشية افضل من الاوقات الاخرى لصب الطبعات.وان تقنية الطبعة الرقمية توفر دقة هامشية افضل من الطبعة التقليدية.