MARGINAL AND INTERNAL FIT EVALUATION OF CAD/CAM ZIRCONIA CROWNS FABRICATED BY STONE DIES VERSUS 3D PRINTED DIES

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ABSTRACT

INTRODUCTION: The recent evolution of digital dentistry along with the newly introduced three-dimensionally (3D) reproduced models in fixed prosthodontics are infrequent.

OBJECTIVES: To assess marginal and internal fit of CAD/CAM zirconia crowns constructed by stone dies versus 3D printed dies.

MATERIALS AND METHODS: A master die was prepared using typodont maxillary molar tooth, duplicated to produce 48 dies and divided into two test groups. Group (I) (n=12) type IV dental stone dies using polyvinyl siloxane for duplication. Group (II) (n=36) A digital scanning system was utilized to produce a scan of the master die, and the images were transformed into standard tessellation language (STL) files. Three different 3D printer types (FormLab2, FormLab3, and Asiga) were utilized to produce three sub groups, twelve specimens each. The specimens were scanned by the digital scanner, followed by fabrication monolithic zirconia crowns and for each group then marginal and internal fit on the master dies were analyzed statistically ($p \leq 0.05$) using the silicone replica technique (SRT).

RESULTS: Stone dies and DLP 3D printer exhibited the lower mean marginal and internal fit values than SLA and LFS with statistically insignificant difference between studied groups.

CONCLUSIONS: A slight significant difference was evident for all groups in favor of DLP 3D printing which had the ability to construct crowns with superior marginal and internal fit than SLA 3D Printing but within an acceptable clinical range and therefore can possibly be utilized in a digital workflow to construct fixed dental prostheses.

KEYWORDS: 3D printing, Marginal and internal fit discrepancy, Monolithic zirconia, Silicon replica technique.

RUNNING TITLE: Marginal and internal fit using stone 3D printed.

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INTRODUCTION

Recent advances in digital technology in dentistry led to significant developments in the treatment concepts of prosthodontics (1).

In restorative dentistry, the digital process which is based on computer engineering is being integrated starting with intraoral scans (i.e., capturing images), all the way to the construction of the final restoration. These digital processes are known as “the digital workflow” (2). However, when the need for this physical model is a must for designing, Standard tessellation language (STL) file could be changed in a resin model using 3D printer technology as the most appreciate method for cast production from digital image with the high precision and quality (3).

The 3D manufacturing procedure could either be subtractive manufacturing (SM) or additive manufacturing (AM). Subtractive manufacturing SM, is based on the concept of milling the material, like computer-aided design and computer-aided manufacturing (CAD-CAM), while AM, is created by the addition of material, like 3D printing (4).

Today, numerous diverse types of 3D printing technologies are offered. These comprise first off, fused deposition modeling (FDM), where layer by layer warm molten material is deposited as filaments; secondly, selective laser sintering SLS, where Ultra-violet light is applied on the powder curing it into the selected design; also, stereolithography SLA, where Ultra-Violet light is utilized in curing the resin laid down in an exact pattern; Additionally, polyjet printing, where a printer is used that squirts photopolymer drops that later solidifies by UV light; and finally the bioprinter, where cells are deposited among water-based films till the tissue is constructed (5). The digital light processing (DLP) mechanism is similar to stereolithography, where light-sensitive resins are polymerized layer by layer. This is a rapid and extremely precise printing mechanism however it is restricted in selection of materials. Digital light processing techniques utilizing ultraviolet lightemitting diodes (LEDs) are deemed superior to DLPs utilizing UV (6).

Successful precise fixed prostheses rely on precise impressions and casts. Conventionally, polyvinyl siloxane (PVS) was the material of choice for impression making due to its superior accurateness and stability (7). As for the die material, type IV dental gypsum stone has been more preferable over epoxy or polyurethane resin (8).

For the assurance of clinical longevity and success of restorations, marginal and internal fit and adaptation is amongst the most imperative conditions to achieve. Inadequacies could result in marginal microleakage, staining, and higher plaque accumulation, possibly causing recurrent caries and/ or start of periodontal disease (9). another important factor is the internal space as it is directly related to the restorations' retention and resistance (10).

The silicone replica technique (SRT) was amongst approaches presented for evaluating the marginal and internal fit, using a similar procedure of cementation of the prosthesis. Though, this technique utilizes silicone as an alternative to cement in the prosthesis thus duplicates internal and marginal fit for analyzing and measuring. Many studies have utilized this technique owing to its simplicity and affordability while still permitting the measurements to be done in the intra-orally directly (11).

The null hypothesis was no significant difference in the accuracy of marginal and internal fit of CAD/CAM zirconia crowns fabricated by the stone dies compared to 3D printed dies when using silicone replica technique.

MATERIALS AND METHODS

A typodont model with interchangeable hard resin teeth was used (Nissan, Kyoto, Japan), stimulating a clinical condition of a maxillary molar tooth which was prepared to be used as a master die for the current study. The die was prepared with the following features; deep chamfer finish line with average 1.5 mm axial reduction, 2 mm occlusal reduction and total convergence angle of 12° (12). (Figure 1).

This master die was scanned using Omnicam (CEREC) for preparation check software to evaluate undercuts, margins -rounded or sharp-, clearance form opposing and adjacent teeth and smooth or rough preparation.

Grouping was made according to the material of tested dies into two main groups. Which monolithic zirconia crown was constructed on, as follows: Group I Stone dies (n=12) while Group II 3D printed resin dies (n=36), which was divided into three subgroups according to the type of printer used (n=12).

Group I: The typodont model was duplicated using conventional impression which was performed using a one-step technique double mix in accordance to the instructions of the manufacturer (Kettenbach GmbH & Co. KG, Panasil Putty Soft, initial contact Light viscosity, Germany). All impressions were allowed to stay for the recommended time by the manufacturer to ensure at room temperature polymerization. After impression removal, it was inspected under magnifying lens for any defects or tearing before it was poured (13).

Impression was sprayed with a surfactant approximately 0.5 ml (Debubblizer Surfactant; Almore International Inc) which decreases the surface tension to enhance the final die quality. Dental stone type IV was mixed under vacuum (Twister Evolution; Renfert) based on the manufacturer's instructions followed by pouring with vibration. Working dies were left for complete setting for 45 minutes before its removal from the impression. This procedure was done twelve times to produce twelve working dies (14). (Figure 2A)

Group II: Regarding the 3D printed dies; The master model was scanned using Omnicam (CEREC) inta-oral scanner. The scanned data was transformed to standard tessellation language (STL files) which is the format needed to produce physical 3D printed dies using three 3D printers to produce twelve 3D printed models in each subgroup; subgroup II-A Stereolethography (SLA) using Formlab (2) 3D printer, subgroup II-B Low force Stereolethography (LFS) using Formlab (3) 3D printer, and subgroup II-C digital light processing (DLP) using Asiga 3D printer with XY resolution of 30-50 µm, layer thickness 25 µm and speed 3cm\hour were used to produce 3D working dies (15). (Figure 2B,2C,2D)

The tested groups were scanned by dental lab scanner (inEos X5, DentsplySirona, Germany), and the design was done according to the standard guidelines provided by the software (Inlab Software DentsplySirona, Germany) and the Zirconia manufacturer for a monolithic Zirconia crown (Cercon HT, DentsplySirona, Germany). Internal space parameter was established to be 50 µm, which was utilized for the ensuing analysis. Twelve monolithic crowns in group I and twelve monolithic crowns per subgroup in group II were milled from Zirconia block, resulting in four experimental groups (16).

Light body silicon (Kettenbach GmbH & Co. KG, Panasil initial contact X-Light viscosity, Germany) simulating cementation material was used during seating of each crown on the tested cast._ Prior to the final setting, all the excess light body material surrounding the crown was smeared away to prevent material ripping. Crown was carefully removed from the tested model with the light body silicon in the fitting surface after polymerization, then another light body silicone (Kettenbach GmbH & Co. KG, Panasil initial contact Light viscosity, Germany) was injected to fill the fitting surface over the previous X-light body film. The Silicone replica master die was removed after silicone polymerization. within 24 hours a blade was used and applied perpendicularly to the surfaces to be examined thus dividing all the replicas: buccolingual and mesiodistal by a single blinded examiner using a ×45 magnification stereomicroscope (Olympus SZ51; Olympus Corp) combined with a digital camera (Topcam XCAM1080PHB, ToupTek Photonics, Zhejiang, China) having a resolution of 0.16 µm per pixel and a specific gauging software (ToupView software, version 3.7, ToupTek Photonics, Zhejiang, China) followed by tuning. The marginal gap, mid-axial (MA), axio-occlusal (AO), and mid-occlusal points of reference were calculated. For every point the measurements were done three times, and the mean value was obtained (17). (Figure 3).

Statistical analysis

Data was statistically analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp) Quantitative data were designated using range (minimum and maximum), mean and standard deviation. Significance of the attained results was set at the 5% level.

The tests used were

1 - One-way ANOVA test

For normally distributed quantitative variables, to compare amongst more than two groups, and Post Hoc test (Tukey) for pairwise comparisons

Figure (1): Prepared ivory tooth in a typodont model.

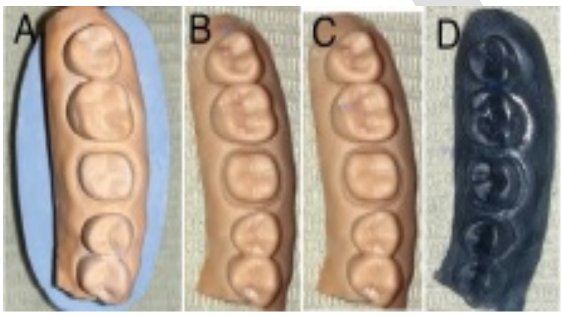

Figure (2): (A) Stone Die (B) SLA Die (C) LFS Die (D) DLP Die.

Figure (3): Steps of replica technique.

RESULTS

This study was conducted to assess marginal and internal fit of CAD/CAM zirconia crowns constructed by stone dies versus 3D printed dies. Quantitative data were calculated using range (minimum and maximum), mean and standard deviation.

Group I: Zirconia crowns over type IV stone model fabricated from conventional additional silicon impression

Group IIA: Zirconia crowns over 3D printed model fabricated from intra-oral scanning (SLA) Stereolithography

Group IIB: Zirconia crowns over 3D printed model fabricated from intra-oral scanning (LFS) Low force Stereolithography

Group IIC: Zirconia crowns over 3D printed model fabricated from intra-oral scanning (DLP) Digital Light Projector

All were evaluated for Marginal and Internal fit at 3 points (Mid-axial, Axio-occlusal and Mid-occlusal) using Silicon Replica Technique

By using One Way ANOVA for statistical analysis of normally distributed quantitative variables, to compare amongst more than two groups, and Post Hoc test (Tukey) for pairwise comparisons.

On comparing marginal gap (MG) in micro-meter In vitro using Silicon Replica Technique (SRT) for the studied groups, in Table (1) and Figure (4) revealed the following:

The lowest mean micro-meter value of the marginal gap was recorded in Group I (19.06 ± 3.87 με), followed by Group IIC (19.83 ± 6.75 με), then Group IIB (21.70 ± 1.90 με), and the highest micro-meter value was noted in Group IIA (22.52 ± 6.12 με). With no statistically significant different between the studied groups.

On comparing Internal Fit (IF) in micro-meter In vitro using Silicon Replica Technique (SRT) for the studied groups, in Table (2) and Figure (5) revealed the following:

The lowest mean micro-meter value of the internal fit was recorded in Group IIC (35.45 ± 2.68 με), followed by Group I (36.04 ± 4.26 με), then Group IIA (36.96 ± 5.29 με), and the highest micro-meter value was noted in Group IIB (43.33 ± 2.06 με). With Statistically significant difference between Group I and Group IIB, Group IIA and Group IIB & Group IIB and Group IIC.

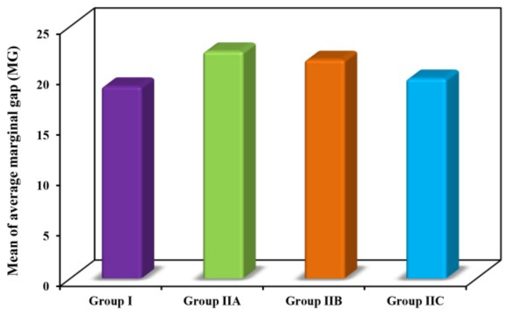

Figure (4): Comparison between the different studied groups according to average marginal gap (MG)

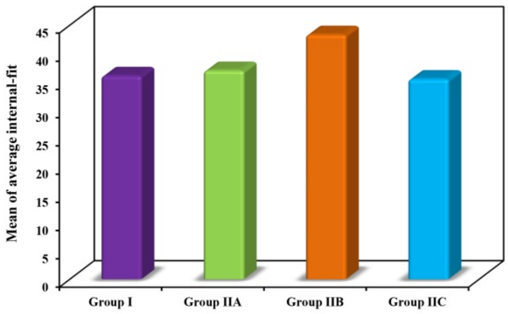

Figure (5): Comparison between the different studied groups according to average internal-fit (IF)

Table (1): Comparison between the different studied groups according to marginal gap (MG) in vitro

Marginal Gap (MG)	Group I (n = 12)	Group IIA (n = 12)	Group IIB (n = 12)	Group IIC (n = 12)	F	p
Average Min. – Max.	13.81 – 23.83	16.60 – 34.20	18.79 – 23.79	14.17 – 33.42	1.215	0.316
Mean ± SD.	19.06 ± 3.87	22.52 ± 6.12	21.70 ± 1.90	19.83 ± 6.75		

SD: Standard deviation
F: F for One way ANOVA test, Pairwise comparison bet. each 2 groups was done using Post Hoc Test (Tukey)
p: p value for comparing between the studied groups
*: Statistically significant at p ≤ 0.05

Table (2): Comparison between the different studied groups according to Internal-Fit in vitro

Internal-Fit	Group I (n = 12)	Group IIA (n = 12)	Group IIB (n = 12)	Group IIC (n = 12)	F	p
Average Min. – Max.	31.27 – 42.38	31.22 – 45.92	40.10 – 45.44	31.03 – 37.40	11.076*	<0.001*
Mean ± SD.	36.04 ± 4.26	36.96 ± 5.29	43.33 ± 2.06	35.45 ± 2.68		
p_1		0.933	<0.001*	0.981		
Sig. bet. grps.		p_2=0.001*,p_3=0.765,p_4 <0.001*				

SD: Standard deviation
F: F for One way ANOVA test, Pairwise comparison bet. each 2 groups was done using Post Hoc Test (Tukey)
p: p value for comparing between the studied groups
p_1: p value for comparing between Group I and each other group
p_2: p value for comparing between Group IIA and Group IIB
p_3: p value for comparing between Group IIA and Group IIC
p_4: p value for comparing between Group IIB and Group IIC
*: Statistically significant at p ≤ 0.05

DISCUSSION

The objective of this in vitro study was to assess marginal and internal fit of CAD/CAM zirconia crowns constructed by conventional stone dies versus three 3D printed dies derived from three printers using several printing mechanisms (SLA, LFS, DLP). The null hypothesis was partly rejected, since stone dies and 3D printed dies exhibited comparable accuracy.

Prosthetic restorations constructed with precise internal fit and high marginal adaptation were chiefly affected by dental casts produced with high dimensional accuracy that simulates original teeth minimizing any discrepancies (18).

Conventional impression using additional silicon with stone die was used as control because it has been established that poly vinyl siloxane impression material possesses higher dimensional accuracy compared to polyether (19). Furthermore, Type IV dental stones exhibits setting expansion that matches the polymerization shrinkage experienced in poly vinyl siloxane (20).

The necessity for traditional conventional approaches in impression making has decreased due to the wide spread of digital workflow and with all the advances in the 3D printer's technology, it has become easier for dentists to incorporate it as part of their clinical practice. Among the uses of 3D printed models are treatment planning, for esthetic and surgical guides procedures (21). Therefore, 3D printing for model fabrication has become a convenient technique now (22).

The employed technology of the machine using the additive technique of 3D printing affects the model production. Dimensional differences due to a number of factors like; the produced minimal layer thickness and shrinkage of the selected material during building or post-curing (23). May produce a significant outcome on the accurateness of the resultant model.
Three-dimensionally printed casts were reported to be just as accurate as the conventional stone models (24). Moreover, 3D printed models have several benefits over their counterparts not only related to accurateness, but also 3D printers are quicker and facilitate consultations with other specialists like the dental technicians (25).

The results of the present study are in accordance with a study assessing the accurateness of casts produced by multiple 3D printing mechanisms, which concluded that the DLP 3D printer resulted in final models as accurate as the conventional model method (26). And also, with another study concluded that Digital light processing (DLP) 3D Printer had the ability to produce crowns with better marginal and internal fit than stereolithography (SLA) 3D Printers (27).

Other investigation, analyzing the accurateness of three dimensionally printed models (utilizing the DLP printer) obtained by computer-generated scans and the accuracy of stone models poured from traditional impressions, it was concluded that 3D printed models deviated more three dimensionally compared to the traditional stone models (28). Another study concluded that traditional gypsum stone casts revealed superior accurateness compared to the digitally produced stone casts and three dimensionally printed photopolymer casts in full arch and prepared teeth (29). On the contrary, the current investigation found that casts printed by the DLP printer revealed three-dimensional accurateness comparable to gypsum models.

While in other studies , SLA did in fact show better accuracy compared to DLP for all teeth with preparations, which was in contrast with the results of the present study (30, 31).

The non-destructive replica technique was selected for both marginal and internal gap evaluation, this technique involved no sectioning to ensure accurate adaptation of the restoration on the die (32).

Several investigations have evaluated the marginal discrepancy values of the crowns. It has been noted that the mean marginal discrepancies of the marginal fit of conventional metal crowns to be below 50 mm (33). On the other hand, CAD-CAM crowns displayed greater mean marginal discrepancy, with a range of 49-83 mm (34). Nevertheless, a definite value for marginal fit accepted clinically is yet to be determined for crown restorations. Authors findings recommended that an open margin of 100 mm - 120 mm is acceptable clinically (35).

CONCLUSION

With the limitation of this study the following findings could be dawn ,

Dies produced by the Asiga (DLP) 3D printer displayed superior accurateness compared to the Formlab 2 and Formlab 3 (SLA & LFS) printers.
comparable marginal and internal fit of Crowns fabricated from the Asiga (DLP) 3D printer group compared to crowns fabricated from the conventional stone dies, both tested groups showed
Crowns fabricated from the three tested groups (Stone dies and 3D printed dies) produced clinically acceptable values and therefore can possibly be utilized in a digital workflow to construct fixed dental prostheses.

CONFLICT OF INTREST
The authors declare that they have no conflicts of interest.
FUNDING
No specific funding was received for this work.

REFERENCES

1. Stansbury JW, Idacavage MJ. 3D printing with polymers: Challenges among expanding options and opportunities. Dent Mater. 2016;32:54-64.
2. Azari A, Nikzad S. The evolution of rapid prototyping in dentistry: a review. Rapid Prototyp J. 2009;15:216-25.
3. Bukhari S, Goodacre BJ, AlHelal A, Kattadiyil MT, Richardson PM. Three-dimensional printing in contemporary fixed prosthodontics: A technique article. J Prosthet Dent. 2018;119:530-4.
4. Keating AP, Knox J, Bibb R, Zhurov AI. A comparison of plaster, digital and reconstructed study model accuracy. J Orthod. 2008;35:191-201.
5. Oberoi G, Nitsch S, Edelmayer M, Janjić K, Müller AS, Agis H. 3D Printing-Encompassing the Facets of Dentistry. Front Bioeng Biotechnol. 2018;6:172.
6. Xie R, Li D, Chao S. An inexpensive stereolithography technology with high power UV-LED light. Rapid Prototyp J. 2011;17:441-50.
7. Stober T, Johnson GH, Schmitter M. Accuracy of the newly formulated vinyl siloxanether elastomeric impression material. J Prosthet Dent. 2010;103:228-39.
8. Derrien G, Sturtz G. Comparison of transverse strength and dimensional variations between die stone, die epoxy resin, and die polyurethane resin. J Prosthet Dent. 1995;74:569-74.

9. Knoernschild KL, Campbell SD. Periodontal tissue responses after insertion of artificial crowns and fixed partial dentures. J Prosthet Dent. 2000;84:492-8.
10. Wiskott HW, Belser UC, Scherrer SS. The effect of film thickness and surface texture on the resistance of cemented extracoronal restorations to lateral fatigue loading. Int J Prosthodont.1999;12:255-62.
11. Praça L, Pekam FC, Rego RO, Radermacher K, Wolfart S, Marotti J. Accuracy of single crowns fabricated from ultrasound digital impressions. Dent Mater. 2018;34:e280-8.
12. Kasem AT, Sakrana AA, Ellayeh M, Özcan M. Evaluation of zirconia and zirconia-reinforced glass ceramic systems fabricated for minimal invasive preparations using a novel standardization method. J Esthet Restor Dent. 2020;32:560-8.
13. Groten M, Axmann D, Pröbster L, Weber H. Determination of the minimum number of marginal gap measurements required for practical in-vitro testing. J Prosthet Dent. 2000;83:40-9.
14. Punj A, Bompolaki D, Garaicoa J. Dental Impression Materials and Techniques. Dent Clin North Am. 2017;61:779-96.
15. Jang Y, Sim JY, Park JK, Kim WC, Kim HY, Kim JH. Evaluation of the marginal and internal fit of a single crown fabricated based on a three dimensional printed model. J Adv Prosthodont. 2018;10:367-73.
16. Burns DR, Beck AD, Nelson SK. A review of selected dental literature on contemporary provisional fixed prosthodontic treatment: Report of the Committee on Research in Fixed Prosthodontics of the Academy of Fixed Prosthodontics. J Prosthet Dent. 2003;90:474-97.
17. Boening KW, Wolf BH, Schmidt AE, Kästner K, Walter MH. Clinical fit of Procera AllCeram crowns. J Prosthet Dent. 2000;84:419-24.
18. Persson AS, Andersson M, Odén A, Sandborgh-Englund G. Computer aided analysis of digitized dental stone replicas by dental CAD/CAM technology. Dent Mater. 2008;24:1123-30.
19. Thongthammachat S, Moore BK, Barco MT, Hovijitra S, Brown DT, Andre CJ. Dimensional accuracy of dental casts: Influence of tray material, impression material, and time. J Prosthodont. 2002;11:98-108.
20. Schaefer O, Schmidt M, Goebel R, Kuepper H. Qualitative and quantitative three-dimensional accuracy of a single tooth captured by elastomeric impression materials: an in vitro study. J Prosthet Dent. 2012;108:165-72.
21. Park ME, Shin SY. Three-dimensional comparative study on the accuracy and reproducibility of dental casts fabricated by 3D printers. J Prosthet Dent. 2018;119:861.
22. Cho SH, Schaefer O, Thompson GA, Guentsch A. Thompson, Arndt Guentsch. Comparison of accuracy and reproducibility of casts made by digital and conventional methods. J Prosthet Dent. 2015;113:310-5.
23. Murugesan K, Anandapandian PA, Sharma SK, Kumar MV. Comparative evaluation of dimensional and surface detail accuracy of models produce by three different rapid prototype techniques. J Indian Prosthodont Soc. 2012;12:16-20.
24. Banjar A, Chen YW, Kostagianni A, Finkelman M, Papathanasiou A, Chochlidakis K, et al. Accuracy of 3D Printed Implant Casts Versus Stone Casts: A Comparative Study in the Anterior Maxilla. J. Prosthodont. 2021;30:783-8.
25. Cortes AR. Digital versus Conventional Workflow in Oral Rehabilitations: Current Status. Appl Sci. 2022;12:3710.
26. Revilla-León M, Gonzalez-Martín Ó, Pérez López J, Sánchez-Rubio JL, Özcan M. Position Accuracy of Implant Analogs on 3D Printed Polymer versus Conventional Dental Stone Casts Measured Using a Coordinate Measuring Machine. J Prosthodont. 2018;27:560-7.
27. Thakare A, Ramesh S, Patil V, Meenakshi S, Ramu R, Byakodi R. Comparative evaluation of internal and marginal fit of interim crowns fabricated by CAD/CAM milling and two different 3D printing systems-An in vitro study. Mater Today Proc. 2022;57.
28. Alshawaf B, Weber HP, Finkelman M, El Rafie K, Kudara Y, Papaspyridakos P. Accuracy of printed casts generated from digital implant impressions versus stone casts from conventional implant impressions: A comparative in vitro study. Clin Oral Implants Res. 2018;29:835-42.
29. Choi JW, Ahn JJ, Son K, Huh JB. Three-Dimensional Evaluation on Accuracy of Conventional and Milled Gypsum Models and 3D Printed Photopolymer Models. Materials (Basel). 2019;12:3499.
30. Kim SY, Shin YS, Jung HD, Hwang CJ, Baik HS, Cha JY. Precision and trueness of dental models manufactured with different 3-dimensional printing techniques. Am. J Orthod Dentofacial Orthop. 2018;153:144-53.
31. Ravi R, Mistry G, Shetty O, Mehta K, Parab S. A comparative evaluation of the accuracy of dental models printed using two different types of 3d printing technologies using a digital inspection software-an in vitro study. Eur J Mol Clin Med. 2018;5:366-79.
32. Wu J, Xie H, Sadr A, Chung KH. Evaluation of Internal Fit and Marginal Adaptation of Provisional Crowns Fabricated with Three Different Techniques. Sensors (Basel). 2021;21:740.
33. Kern M, Schaller HG, Strub JR. Marginal fit of restorations before and after cementation in vivo. Int J Prosthodont.1993;6:585-91.
34. Brawek PK, Wolfart S, Endres L, Kirsten A, Reich S. The clinical accuracy of single crowns exclusively fabricated by digital workflow-the comparison of two systems. Clin Oral Invest. 2013;17:2119-25.
35. Holmes JR, Sulik WD, Holland GA, Bayne SC. Marginal fit of castable ceramic crowns. J Prosthet Dent.1992;67:594-9.