ORIGINAL RESEARCH

Internal Adaptation and Marginal Accuracy of Two Different Techniques-based Poly (ether ether ketone) Single Crowns: An *In Vitro* Study

Ahmed Rizk Ali Mostafa[1], Samaa Nagy Kotb[2], Omnia Abdel-Hamid El-Shihy[3]

Abstract

Purpose: The goal of this study was to evaluate how different fabrication techniques affected the marginal accuracy and internal adaptability of poly (ether ether ketone) (PEEK) molar single crowns.

Materials and methods: Twenty PEEK crowns were constructed using two different fabrication techniques, and they were divided into two main groups (PEEK-CAD and PEEK-pressed). PEEK-CAD crowns were numbered from 1 to 10. PEEK-pressed crowns were numbered from 11 to 20. Each group had 10 PEEK crowns, and both were constructed over a master die. For internal fit measurements, silicone replica bodies were built and cut into two halves buccolingually. Marginal accuracy was measured using three evenly spaced landmarks along the specimen's cervical circumference on each surface using a Leica L2 APO* microscope.

Results: In terms of marginal accuracy, the Press group had a statistically significant greater mean marginal gap value than the computer aided-designing (CAD) group. While in terms of internal fit, there was no statistically significant difference in internal fit between the CAD and Press groups. At a significance level of two-tailed p-value = 0.21 ($p > 0.05$).

Conclusion: PEEK-CAD crowns demonstrated higher marginal accuracy and nearly similar internal fit when compared to PEEK-pressed crowns.

Clinical significance: PEEK material could be used as a substitute for zirconia for a full coverage posterior restoration.

Keywords: CAD–CAM technique, Internal fit, Marginal adaptation, PEEK and Press techniques.

The Journal of Contemporary Dental Practice (2022): 10.5005/jp-journals-10024-3429

Introduction

Ceramic restorations are preferred over metal–ceramic restorations due to their improved aesthetics, biocompatibility, great abrasion resistance, superior mechanical qualities, and low thermal conductivity.[1] The use of materials like lithium disilicate and 3 mol% yttria-stabilized tetragonal zirconia polycrystal (3Y-TZP) in prosthetic dentistry has been made possible by the development of these materials and innovative processing techniques; however, their brittleness and the competency of the marginal precision have been questioned.[1] Poly(aryl ether ketone) (PAEK), PEEK, and poly(ether ketone ketone) (PEKK) materials are examples of high-strength resins that have been developed as a viable substitute for ceramic materials. In orthopedic surgery requiring load-bearing spinal cage systems, PAEK has been used as a bone substitute material for many years in the aerospace sector. The material offers good mechanical stability, corrosion resistance, and biocompatibility.[1] PEEK, the most popular variety of PAEK resin, is a thermoplastic high-performance polymer (HPP) with a partly crystalline structure that is made of an aromatic backbone molecular chain joined by ketone and ether functional groups.[2,3] PEEK has a glass transition temperature of roughly 143°C and a melting temperature of roughly 334°C. It is also very resistant to heat deterioration. In comparison to zirconia, which has Young's modulus of 200 GPa, PEEK has Young's modulus of about 3–4 GPa, which is similar to that of human bone.[1]

Marginal adaptation is thought to be a key element in the success of restorations. The retention of the prosthesis is increased by excellent marginal fit. While improperly fitted margins can cause pulp exposure, tooth sensitivity, recurrent caries, cement disintegration, and periodontal issues. Moreover, margins tend to discolor leading to esthetic failure, although there is not a set standard for what constitutes clinically acceptable marginal accuracy.

The gap of 120 Mm has been described as the highest marginal gap that is appropriate for clinical use. Internal fit is defined as the degree of approximation or fit of filling material or dental restoration to the tooth surface. It is considered the main parameter for the fracture resistance and retention form for the tooth-restoration complex. PEEK-CAD crowns were characterized by their better marginal accuracy due to the recent advancements in the scanning technology leading to precise detection of the preparation margin and advanced milling technology and allowing

[1]Department of Fixed Prosthodontics, Faculty of Dentistry, Cairo University, Cairo, Egypt; Fixed Prosthodontic Department, Faculty of Dentistry, Modern Technology and Information (MTI) University, Cairo, Egypt

[2,3]Department of Fixed Prosthodontics, Faculty of Dentistry, Cairo University, Nasr city, Cairo, Egypt

Corresponding Author: Ahmed Rizk Ali Mostafa, Department of Fixed Prosthodontics, Faculty of Dentistry, Cairo University, Cairo, Egypt; Fixed Prosthodontic Department, Faculty of Dentistry, Modern Technology and Information (MTI) University, Cairo, Egypt; Phone: +0128 1300008, e-mail: ahmedrizk.aly@dentistry.cu.edu.eg

How to cite this article: Mostafa ARA, Kotb SN, El-Shihy OAH. Internal Adaptation and Marginal Accuracy of Two Different Techniques-based Poly (ether ether ketone) Single Crowns: An *In Vitro* Study. J Contemp Dent Pract 2022;23(11):1106–1110.

Source of support: Nil

Conflict of interest: None

for a chair-side restoration fabrication in a single visit, but its main limitation was overshooting phenomena during the scanning process. While the advantages of PEEK-pressed crowns were better internal fit as they involved a less complicated process, using a more manual than computer program computation. But their limitations were too many visits and many steps for the final delivery.[4–7] There is limited information about the influence of fabrication technique on the marginal accuracy and internal fit of PEEK restorations. So, the purpose of this study is to evaluate the influence of different fabrication techniques on the marginal accuracy and internal adaptation of PEEK single restorations in *in vitro* study to know if it could be applicable to be used *in vivo* after that or not.

Materials and Methods

Study Design

This study was conducted *in vitro*.

Sample Size Calculation

A G*Power version 3.1.9.7 power analysis was designed to have adequate power to apply a statistical test of the null hypothesis that there is no difference would be found in the marginal precision of PEEK copings produced by different fabrication techniques. By adopting an α level of 0.05, a β level of 0.2, i.e., power = 80%, and an effect size (d) of 3.53 (calculated based on the results of Attia et al.[1]), the predicted sample size (n) was a total of 10 samples. The sample size calculation was performed using G*Power version 3.1.9.7.

Study Groups

Twenty PEEK crowns are built using two distinct fabrication processes and divided into two groups of 10 ($n = 10$, PEEK-CAD and PEEK-pressed). Each group had 10 crowns. Under supervision, the researcher was responsible for all operations, including typodont preparation, replica technique, internal fit, and marginal accuracy assessment.

Sample Preparation Using a Master Die

The typodont teeth were prepared to a height of 4.5 mm, a uniform chamfer finish line of 1.0 mm in width, a total angle of convergence of 10°, a mean of 6° convergence of the axial walls, and a uniform anatomical occlusal anatomical reduction of 2.0 mm was made in functional and nonfunctional cusps. Before teeth were reduced, a putty index was made to be used as a reference and was cut buccolingually. After the preparation was done, the AF 30 NOUVAG parallelometer was used to assess the taper's degree.

Randomization and Blinding

PEEK crowns were numbered from 1 to 20. PEEK-CAD crowns were numbered from 1 to 10, while PEEK-pressed crowns were numbered from 11 to 20, where each group has 10 crowns and both are constructed over the master die.

Fabrication of PEEK-CAD Crowns

The die was scanned with a laser using an extraoral optical scanner. A virtual image of the prepared tooth was created to create the PEEK-CAD crown after the typodont was inserted in the multi-die holder for scanning by the 3Shape E4 scanner TRIOS® 3 (3Shape) A/S and designing by the Ceramill4E2 Exocad CAD/computer-aided manufacturing (CAM) Software using PEEK blank (bioHPP®). The design settings for the CAD program were set as follows: 1.5 mm axial thickness, 2 mm occlusal thickness on functional and nonfunctional cusps, and 50 m cement space that is 1 mm short of the borders (Fig. 1).

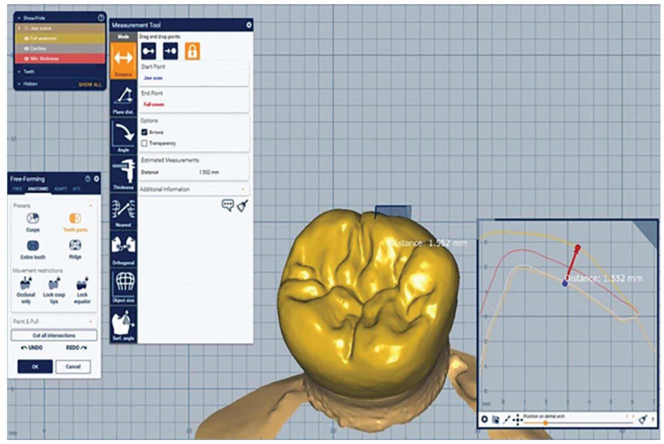

Fig. 1: Design parameters of virtual crown showing estimated axial thickness on CAD software

Fabrication of PEEK-pressed Crowns

A PEEK-pressed crown was created using a CAD wax that was milled using the same standard tessellation language (STL) file, and the same dimensions as the CAD–CAM PEEK crowns that had previously been built. Sprues with 4 mm diameter and 4 mm length were attached to the wax copings and then invested in a phosphate-bonded investment material. The silicone mold was heated in a furnace [Ibex Dental Furnace (A-130)] for wax elimination to 630°C for 90 minutes for PEEK pellets and left to cool at a cooling rate of 8°C/minute until 400°C. After casting, the PEEK-pressed crown is obtained after complete solidification and finally finished by Komet bur.

Construction of Silicone Replica Body

The intaglio replicas were made of light-body and heavy-body silicone impression materials. A razor blade was used to cut the replicas into two equal pieces in the buccolingual directions. A light-body material was injected first into each crown. Then, the crown was seated on the tooth with finger pressure and excess impression material was removed immediately. After complete setting, the crown was removed from the tooth carefully by the explorer. Then, a heavy body material was mixed in a ratio 1:1 using automix impression gun and injected inside the crown (with the set light body material attached over the fitting surface of the crown) was inserted until the finish line was completely immersed and left to set.

Vertical Margin Gap Measurements

The vertical marginal gap was measured using a stereomicroscope Leica L2 APO at a 16× magnification. The images are taken using a built-in camera. The Leica Application Suite (LAS) version 4.0 software processes images on an Acer computer connected to the microscope.

The software measures the distance in millimeters, considering three equally spaced landmarks along the cervical circumference for each surface of the specimen, from a point chosen on the crown border and another point on the typodont finish line. After that, the data were gathered, tabulated, and then statistical analysis was performed on them.

Internal Fit Measurements

The replica technique was used to measure internal discrepancy. Using a sharp lancet, all replica bodies were divided into two relatively equal parts in buccolingual directions from the center point. Each replica body's individual sections were placed on a surface resembling clay and placed in front of a Leica L2 APO digital microscope for measurement and photography. Measurements were taken at six points, including the cusp tip (highest point) and central fossa, for replica body sections (deepest point).

Outcome Analysis

Analysis was performed using SPSS GraphPad prism and Microsoft Excel 2016. Data were represented as mean and standard deviation (SD).

Statistical Analysis

Data were explored for normality by using Shapiro–Wilk and Kolmogorov–Smirnov normality tests, which revealed that all data were parametric data (p-value > 0.05).

Accordingly, comparisons between the two groups were performed by using a one-way analysis of variance test followed by Tukey's *posthoc* test for multiple comparisons.

Results

Internal Fit

The mean and SD for each group's internal fit were displayed in Table 1. The CAD group results were recorded to be associated with internal fit values M = 393.74 (SD = 151.99). By comparison, the internal fit values in the Press group were recorded to be M = 292.63 (SD = 64.97). The Kolmogorov–Smirnov test revealed that the p-value was 0.2 in the CAD group and 0.2 in the Press group. Also, the Shapiro–Wilk test (normality test) revealed that the p-value was 0.62 in the CAD group and 0.47 in the Press group (Table 2).

The independent t-test revealed no statistically significant difference between the CAD group and Press group with a recorded significance value (two-tailed p-value) = 0.21.

Marginal Gap

Table 3 shows the mean and standard deviation values for internal fit for different groups. The CAD group results were recorded to be associated with vertical marginal gap values of mean and SD (12.64 ± 1.72). In comparison, the marginal gap values in the Press group were M = 25.55 (SD = 2.48 m). The Kolmogorov–Smirnov test revealed that the p-value was 0.2 in the CAD group and 0.2 in the Press group. Also, the Shapiro–Wilk test (normality test) revealed that the p-value was 0.36 in the CAD group and 0.78 in the Press group as shown in Table 4.

As a result, the Press group had a statistically significant greater marginal gap mean value than the CAD group. So, the milled PEEK showed better marginal precision than pressed ones.

Table 1: Internal fit values for several groups, including mean and standard deviation

	Group statistics					
	Study groups	*Mean*	*Std. deviation*	*Std. error mean*	*Min.*	*Max.*
Internal fit	CAD group	393.74	151.99	67.97	239.06	633.31
	Press group	292.63	64.97	29.06	187.01	359.29

Table 2: Results of the normality test for the study groups

	Tests of normality						
		Kolmogorov–Smirnov			*Shapiro–Wilk*		
	Study groups	*Statistic*	*df*	*Sig.*	*Statistic*	*df*	*Sig.*
Internal fit	CAD group	0.22	5	0.20	0.93	5	0.62
	Press group	0.26	5	0.20	0.91	5	0.47

Table 3: Marginal gap values for several groups, including mean and standard deviation

	Group statistics					
	Study groups	*Mean*	*Std. deviation*	*Std. error mean*	*Min.*	*Max.*
Marginal gap	CAD group	12.64	1.72	0.76913	9.98	14.14
	Press group	25.55	2.48	1.11097	22.93	29.11

Table 4: Results of the normality tests for the study groups

	Tests of normality						
		Kolmogorov–Smirnov			*Shapiro–Wilk*		
	Study groups	*Statistic*	*df*	*Sig.*	*Statistic*	*df*	*Sig.*
Marginal gap	CAD	0.207	5	0.200	0.891	5	0.364
	Press	0.177	5	0.200	0.956	5	0.781

Discussion

Poly(ether ether ketone), a prominent member of the PAEK polymer family, was introduced in the dental industry throughout the 1990s as the major replacement for the metallic components for implants, particularly in cases of orthopedics and trauma. It was demonstrated that it has great thermal and chemical stability, nontoxic, and is naturally radiolucent.[8–11]

PEEK has Young's modulus of elasticity in the range of 3–4 GPa. It has a melting point of 335°C. It has a low density (1.32 g/cm^3) and is very light. It is a physiologically inert substance. It is also resistant to deterioration during different sterilizing methods. It is inexpensive and has great abrasion resistance.[2,3]

PEEK material can be produced by casting under heat and pressure as well as the CAD–CAM technology and the wax waste management method.[1]

The accuracy of fit of fixed dental restorations is usually defined by measuring parameters like a marginal and internal gaps. The risk of subsequent caries, cement dissolutions, and gum inflammations is decreased by adequate marginal adaption. Additionally, the internal fit significantly affects the mechanical characteristics of the restorations in terms of retention and fracture resistance.[12–15]

The CAD–CAM technology was chosen due to its ability to control the thickness and anatomy of restorations during the fabrication process. Many potentially confounding operator variables were avoided such as procedures involved in the fabrication process however, Pressing technology exhibit predictable results.[16,17]

For standardization of all samples to avoid any variables that may change the final result, all samples subjected to same steps according to each group either CAD group or Pressed group.

The CAD parameters on the designing software were standardized for all crowns with cement space of 50 μm and 1 mm short of the margins based on the pilot study done before to achieve consistent and reliable results; in addition, the crowns investigated were not cemented, as cement thickness may affect the marginal precision of the restorations.

For the pressed group, CAD wax was milled from the same STL file used for milling PEEK-CAD crowns to ensure standardization of cement gap and crown thickness.

The silicone replica technique was used in our study to evaluate the internal fit before cementation. It is a commonly used nondestructive technique. Researchers prefer it over other destructive techniques because it saves specimens for further laboratory investigations to test other material properties, However, the impression replica technique has its constraints and inherent errors such as difficulty in identifying the crown margins and finishing lines, and tearing of the elastomeric film upon removal from the crown.[18–23]

The vertical cervical marginal gap was measured using direct viewing with external measurements with the help of a stereomicroscope. All measurements were made by the same operator for standardization. The method used in this study has the advantage of not being invasive and therefore applicable to clinical practice.[24–27]

The obtained vertical marginal gap results in this study were consistent with those of Attia et al.,[1] who evaluated the effect of different fabrication techniques on the marginal precision of PEEK single-crown copings. It was found that the values of the mean marginal gap were 72 ± 9 mm for the PEEK pellet group and 45 ± 6 mm for the PEEK CAD–CAM group.

While internal fit results of the present study were coincident with the previous study by Beuer et al.,[28] who evaluated the marginal and internal fit of copings fabricated from PEEK and zirconia. It was found that there was no statistically significant difference between the three groups as $p = 0.36$ (>0.05). The PEEK-pressed result was 112 ± 40 μm), while the PEEK-CAD result was 130 ± 40 μm.

The results of the present study were coincident with the previous study by Makky et al.,[29] who evaluated the marginal and internal fit of copings fabricated from PEEK and zirconia. It was found that there was no statistically significant difference between the three groups as $p = 0.36$ (>0.05). The PEEK-pressed result was 112 ± 40 μm, while the PEEK-CAD result was 130 ± 40 μm. So, the PEEK-pressed showed better internal fit and this may be due to the fact that the pressed technique involves a less complicated process, using a more manual than computer program computation, and is process dependent.

The results of the current study and those of other studies may differ due to different measurement techniques, the number of sample size, the study design (*in vitro* not *in vivo*), different types of measuring microscopes available, the use of magnification, measurement sites, and the quantity of samples.[2,20,21]

The study was carried out on single crowns only; thus, further research should be performed on fixed partial dentures and the 2D silicone replica technique used involves sectioning of the silicone which might lead to the loss of data.

More research is needed to investigate the effect of manufacturing technique on the fracture resistance of PEEK restorations and to investigate the impact of various milling machine axes on marginal accuracy.

Further studies are required to examine the effect of fabrication on the fracture resistance of PEEK restorations and also to examine the effect of different milling axes on marginal accuracy and clinical application of the present trial to support or negate the results of our study.

Conclusion

Poly (ether ether ketone) CAD–CAM crowns exceeded PEEK-pressed crowns in terms of marginal accuracy and internal fit. However, both materials demonstrated marginal accuracy within clinically acceptable limits of <120 m.

References

1. Attia MA, Shokry TE. Effect of different fabrication techniques on the marginal precision of polyetheretherketone single-crown copings. J Prosthet Dent 2020;24(5):565.e1–565.e7. DOI:10.1016/j.prosdent.2020.04.003.
2. Al-shalan A, Arwa A, Aldin D, et al. Marginal and internal fit of CAD CAM system: A literature review. The Saudi Dental Journal 2019;31:S21. https://doi.org/10.1016/j.sdentj.2019.01.023.
3. Att W, Komine F, Gerds T, et al. Marginal adaptation of three different zirconium dioxide three-unit fixed dental prostheses. J Prosthet Dentist 2009;101(4):239–247. DOI:10.1016/S0022-3913(09)60047-0.
4. Abduo J, Lyons K. Rationale for the use of CAD/CAM technology in implant prosthodontics. Int J Dent 2013;2013:768121. DOI:10.1155/2013/768121.
5. Stawarczyk B, Eichberger M, Uhrenbacher J, et al. Three-unit reinforced polyetheretherketone composite FDPs: influence of fabrication method on load-bearing capacity and failure types. Dent Mater j 2015;34(1):7–12. DOI:10.4012/dmj.2013-345.

6. Bathala L, Majeti V, Rachuri N, et al. The role of polyether ether ketone (PEEK) in dentistry – A review. J Med Life 2019;12(1):5–9. DOI:10.25122/jml-2019-0003.
7. Boitelle P, Tapie L, Mawussi B, et al. Evaluation of the marginal fit of CAD-CAM zirconia copings: comparison of 2D and 3D measurement methods. J Prosthet Dent 2018;119:75–81. DOI:10.1016/j.prosdent.2017.01.026.
8. Ayad MF. Effect of the crown preparation margin and die type on the marginal accuracy of fiber-reinforced composite crowns. J Contemp Dent Pract 2008;1:9–16. PMID:18264520.
9. Rustum M, Gonzalez MA, Abu Kasim NH, et al. Effect of operators' experience and cement space on the marginal fit of an in-office digitally produced monolithic ceramic crown system. Quintessence Int 2016;47(3):181–191. DOI:10.3290/j.qi.a34722.
10. Beschnidt SM, Strub JR. Evaluation of the marginal accuracy of different all-ceramic crown systems after simulation in the artificial mouth. J Oral Rehabil 1999;26(7):582–593. DOI: 10.1046/j.1365-2842.1999.00449.x.
11. Bosch G, Ender A, Mehl A. A 3-dimensional accuracy analysis of chairside CAD/CAM milling processes. J Prosthet Dent 2014;112(6):1425–1431. DOI:10.1016/j.prosdent.2014.05.012.
12. Costa-Palau S, Torrents-Nicolas J, Brufau-de Barberà M, et al. Use of polyetheretherketone in the fabrication of a maxillary obturator prosthesis: a clinical report. J Prosthet Dent 2014;112(3):680–682. DOI:10.1016/j.prosdent.2013.10.026.
13. Özal Ç, Ulusoy M. In-vitro evaluation of marginal and internal fit of 3-unit monolithic zirconia restorations fabricated using digital scanning technologies. Journal of Advanced Prosthodontics 2021;13(6):373. DOI:10.4047/jap.2021.13.6.373.
14. Rekow D. Computer-aided design and manufacturing in dentistry: A review of the state of the art. J Prosthet Dent 1987;58(4):512–516. DOI:10.1016/0022-3913(87)90285-x.
15. De Oliveira DW, Maravilha MN, Dos Anjos TN, et al. Clinical and radiographic evaluation of the periodontium with biologic width invasion by overextending restoration margins-a pilot study. J Int Acad Periodontol 2015;17(4):116–122. PMID:26727150.
16. El-Ashkar A, Taymour M, El-Tannir A. Evaluation of the marginal and internal gaps of partially crystallized versus fully crystallized zirconia-reinforced lithium silicate CAD-CAM crowns: An in vitro comparison of the silicone replica technique, direct view, and 3-dimensional superimposition analysis. J Prosthet Dent 2021;S0022-3913(21)00419-4. DOI:10.1016/j.prosdent.2021.07.024.
17. Kosyfaki P, del Pilar Pinilla Martín M, Strub JR. Relationship between crowns and the periodontium: a literature update. Quintessence Int. 2010;41(2):109–126. PMID:20165743.
18. Georgiev J, Vlahova A, Kissov H, et al. Possible application of BioHPP in prosthetic dentistry: A literature review. J IMAB–Ann Proc Sci Paper 2018;24(1):1896–1898. DOI:10.5272/jimab.2018241.1896.
19. Ghodsi S, Alikhasi M, Soltani N. Marginal discrepancy of single implant-supported metal copings fabricated by various CAD/CAM and conventional techniques using different materials. European J Dent 2019;13(04):563–568. DOI:10.1055/s-0039-1700364.
20. Park JY, Bae SY, Lee JJ, et al. Evaluation of the marginal and internal gaps of three different dental prostheses: comparison of the silicone replica technique and three-dimensional superimposition analysis. J Adv Prosthodont 2017;9(3):159–169. DOI:10.4047/jap.2017.9.3.159.
21. Najeeb S, Zafar MS, Khurshid Z, et al. Applications of polyetheretherketone (PEEK) in oral implantology and prosthodontics. J Prosthodont Res 2016;60(1):12–19. DOI:10.1016/j.jpor.2015.10.001.
22. Demir N, Ozturk AN, Malkoc MA. Evaluation of the marginal fit of full ceramic crowns by the microcomputed tomography (micro-CT) technique. Eur J Dent 2014;8(4):437–444. DOI:10.4103/1305-7456.143612.
23. Dauti R, Lilaj B, Heimel P, et al. Influence of two different cement space settings and three different cement types on the fit of polymer-infiltrated ceramic network material crowns manufactured using a complete digital workflow. Clin Oral Investig 2020;24(6):1929–1938. DOI:10.1007/s00784-019-03053-1.
24. Mansour FK, Ibrahim RM, Mansour H, et al. Assessment of internal fit and micro leakage of conventionally fabricated ceramometallic restoration versus CAD wax and press veneering (in-vitro study). BDJ Open 2021;7(1):1–6. DOI:10.1038/s41405-021-00072-7.
25. Kale E, Seker E, Yilmaz B, et al. Effect of cement space on the marginal fit of CAD-CAM-fabricated monolithic zirconia crowns. J Prosthet Dent 2016;116(6):890–895. DOI: 10.1016/j.prosdent.2016.05.006.
26. Azarbal A, Azarbal M, Engelmeier RL, et al. Marginal fit comparison of CAD/CAM crowns milled from two different materials. J Prosthodont 2018;27(5):421–428. DOI:10.1111/jopr.12683.
27. Lee KB, Park CW, Kim KH, et al. Marginal and internal fit of all-ceramic crowns fabricated with two different CAD/CAM systems. Dent Mater J 2008;27(3):422–426. DOI: 10.4012/dmj.27.422.
28. Beuer F, Schweiger J, Eichberger M, et al. High-strength CAD/CAM-fabricated veneering material sintered to zirconia copings—a new fabrication mode for all-ceramic restorations. Dent Mater 2009;25(1):121–128. DOI:10.1016/j.dental.2008.04.019.
29. Makky MR, Shokry TE, et al. Comparison of marginal and internal fit of copings Fabricated from polyetheretherketone and zirconia: An in-vitro study. Al-Azhar J Dent Sci 2020;23(4):355–362. DOI:10.21608/AJDSM.2020.26019.1035.