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Influence of Direct and Indirect Digital Data Capturing Techniques on Marginal Accuracy and Internal Fit of CAD/CAM Fabricated PEEK and Zirconia Crowns

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ABSTRACT

Purpose: The aim of this study was to evaluate the marginal and internal fitness of PEEK and Zirconia crowns fabricated by three different impression techniques. **Materials and methods:** Thirty standardized acrylic die models were prepared. Dies were divided into two main groups (n= 15): Group 1**:** CAD/CAM fabricated zirconia crowns. Group 2**:** CAD/CAM fabricated PEEK crowns. Each group was subdivided into three subgroups (n= 5), according to the impression technique using for data acquisition: Sub-group (A): direct digital scans of the model used intraoral digital scanner. Sub-group (B): indirect digital scans of the silicon impressions using extraoral scanner. Sub-group (C): indirect digital scans of the stone casts obtained from silicon impressions using extraoral scanner. Crowns were then designed and fabricated. Marginal and internal gaps were measured using silicone replica technique and field digital microscope. **Results:** Independent t-test was used for comparison between groups. Comparisons between subgroups were performed by one-way analysis of variance (ANOVA) test, followed by Bonferroni's post hoc test. In Zirconia group, the highest mean value was recorded in stone cast scan group, followed by intraoral scan, with the least value recorded in impression scan subgroup. In PEEK group, the highest mean value was recorded in stone cast group, followed by impression scan, with the least value recorded in intraoral scan subgroup. **Conclusions:** All tested crowns showed marginal gap distance values within the clinically acceptable levels. PEEK crowns had lower vertical marginal gap distance than zirconia crowns with different scanning techniques.

KEYWORDS

Intraoral scanner, Extraoral scanner, Marginal gap distance.

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INTRODUCTION

The growing interest in tooth-colored high-performance polymers attributed to the sustained support in CAD/CAM technology, easier processing and cheap cost as well as enhancement of mechanical properties in combination with the advantages of using them in thinner thicknesses as compared to ceramics[1]. 3D scanners are considered one of the digital methods used for this purpose which composed of a light source, camera and a motion system supporting several axes for positioning the scanned object towards the light source and camera(s). The light source focuses a well-defined line into the surface of the object, and the camera(s) capture images of the lines.

Depending on the known angle and distance between camera and light source (jointly called the scan head), the 3D position (s) where the projected light is reflected can be calculated using trigonometry. The marginal fit of any restoration is one of the important factors for successful prosthetic treatment[2]. An ideal marginal fit maintains a healthy periodontal status and prevents failure of restoration[3]. On the other hand, improper marginal fit has a negative effect on the periodontium, making it difficult to perform long-term maintenance of the patient's health following restoration cementation[4]. SRT (silicone replica technique) is one of the methods used to measure marginal accuracy by injecting silicone material inside the prosthesis. This method is easier and simple; it has been utilized in many studies [5]. however, it can make assessments only using two-dimensional (2D) analysis.

The triple scan method (TSM) technique depends on scanning of abutment and prosthesis during try in step to calculate the internal and marginal gap by software. It is a nondestructive but have some drawbacks due to possible inaccuracy and overlapping of the scanned data [6]. Micro-computed tomography (MCT) technique depends on obtaining a 3d image [7]. Optical coherence tomography (OCT) technique is a non-destructive, non-radiological method using higher resolution 2D or 3D images in optical scattering media using coherent light [9]. The present study will be directed to investigate the influence of direct and indirect digital data capturing techniques on marginal accuracy and internal fit of CAD/CAM fabricated peek and zirconia crowns. The null hypothesis for this in vitro study is rejected as there is a statistically significant differences in marginal and internal gaps values between zirconia and PEEK crowns in the three scanning techniques.

MATERIALS AND METHODS

Sample size estimation and statistical power:

The calculation was estimated using CDC Epi Info program version 7.2.0.1 (Atlanta, USA) assuming a power of 80% and alpha=0.05 to detect significant difference in marginal and internal fitness of peek and zirconia crowns fabricated by three different impression techniques. A total of 30 samples (10 each subgroup) is needed based on an estimated difference in mean of vertical marginal gap distance values of 42.34 ± 2.54 in Sub-group directly scanned by intraoral scanner and 48.48 ± 1.01 in Sub-group scanned silicon impressions by extraoral scanner compared to 64.74 ± 3.32 in Subgroup scanned stone cast by extraoral scanner[10].

Teeth selection and preparation:

Thirty standardized typodont acrylic die models(Frasaco GmbH, Tettnang, Germany) were prepared representing first molar all-ceramic preparation with 4mm preparation height, 6-degree convergence angle and 1.5mm shoulder margin[11]. Crowns were fabricated and divided into two groups (15 crowns each) according to the type of material.

Group I: CAD/CAM fabricated zirconia (Nacera Kurary Noritke dental Ince Germany) crowns. **Group II:** CAD/CAM fabricated PEEK (breCAM GmbH&Co.KG Germany) crowns. Each group was subdivided into three sub groups (n=5) according to the scanning technique. Sub-group

(A): direct digital scans of the model using intraoral digital scanner (Trios 3, 3 shape, Copenhagen, Denmark). Sub-group (B): Indirect digital scans of silicon impressions using extraoral scanner (E2 Lab scanner, 3 shape, Copenhagen, Denmark). Sub-group (C): Indirect digital scans of stone casts obtained from silicon impressions using extraoral scanner (E2 Lab scanner, 3 shape, Copenhagen, Denmark).

Scanning of acrylic models (direct scanning):

The acrylic models were digitally scanned (ten scans) using an intraoral scanner (Trios 3, 3 shape, Copenhagen, Denmark) with a powder-free technology. The scanner was held closely over acrylic die. The resulting scans were then converted to STL format and sent directly to the lab. At the dental lab, the digital data obtained from the scanning process was processed to create virtual models using CAD system software. Data were transported to a computer connected to the milling machine to analyze and start milling full-contour monolithic zirconia and PEEK crowns.

Scanning of the silicon impressions (Extraoral scanning):

A single-step, double consistency ten full-arch addition silicon impressions of the typodont models were made by injecting light body material (Elite, Zhermack, Italy), after being auto-mixed over the prepared acrylic die meanwhile the heavy body addition silicon was loaded in a custom tray and seated over the model. The silicon impressions were removed from the typodont model after complete setting, and sprayed with light reflecting powder (Occlutec ,Scanspray .Renfert GmBh .U.S.A). Finally, they underwent extraoral scanning using a laboratory scanner (E2 Lab scanner, 3 shape, Copenhagen, Denmark).The resulting scans were then converted to STL format and sent directly to milling machine.

Scanning of stone casts (Extraoral):

A single-step full-arch ten silicon impressions (Elite, Zhermack, Italy) were taken as described before. After 30 minutes, each impression was poured in Type IV dental stone (Shera premium type IV, SHERA, Germany) by the same technician manually following the manufacturer's recommendations on a vibrator to obtain ten stone casts free from any voids. After setting of the stone (16 min), the casts were separated from the impressions, sprayed by telescan spray (DFS-DIAMON, GmbH) and then scanned using the same laboratory scanner. Designing and milling processes were performed similar to subgroup A.

Construction of zirconia Crowns:

The crowns design was manipulated by Dental system software (2016v 1.6.3, 3Shape, Copenhagan, Denmark) and sent to the milling machines to fabricate Zirconia (Nacera blanks) crowns.

Milling of Zirconia Crowns:

Zirconia discs were inserted into 5-axis milling machine (Roland DWX-51D, Japan). The crowns were milled with 25% enlargement in size to compensate for the sintering shrinkage. After the milling process the crowns were separated from the zirconia disc by using a specific finishing bur. All crowns were then cleaned using an ultrasonic bath of distilled water for 10 minutes to remove any residues. The crowns were then placed into the drying system for 5 minutes at a temperature of 80°C.

Sintering of Zirconia Crowns:

The crowns were then placed into inFire HTC speed furnace (Sirona, Germany) and sintered at 1600°C for a total firing time of 12 hours as recommended by the manufacturer. Finally, all crowns were cleaned with distilled water for 5 minutes in ultrasonic bath cleaner to remove any contamination from the manufacturing process.

Construction of PEEK crowns:

For the PEEK (bre-CAM BioHpp) group, models were scanned as previously described for the zirconia group. Designing was done by dental CAD/CAM Software (2016v 1.6.3, 3Shape, Copenhagan, Denmark). The material thickness was standardized according to the recommended values which are 0.7 mm PEEK and a spacer of 40μ between the coping and the prepared tooth. The PEEK blank was milled using 5-axis milling machine.

PEEK veneering:

Surface treatment of Peek copings was made to improve the wettability of copings by airborne-particle abrasion followed by adding the bond (visio. link) with as recommended by manufacturer instructions. Composite veneer builds up was achieved by manual layering of composite (crea. Lign).

Testing procedures:

Marginal and internal gap measurements:

A non-destructive impression method (silicone replica technique) was used to measure the marginal and internal gaps for all crowns. This method duplicates the distance between the inner surface of the crowns and master model surface by measuring the thickness of light body silicon impression.

Replica technique:

The internal surface of the crown was injected by Polyvinyl siloxane addition silicone impression materials a light body blue-colored (Elite, Zhermack, Italy) then seated on the master die simulating the cementation procedure. A constant load (50 N) was applied for 2 minutes along the major axis of the crown using a holding device until the impression material completely sets. Once the material set, the crown was gently separated from the die to obtain a thin layer of material adhering to the internal surface of the crown. This film was supported by adding a by Polyvinyl siloxane addition material(Express XT, medium body, 3M ESPE, Germany) (violet color). to fill the fitting surface of the crown. Once the medium body completely set, the replicated die was gently separated from the crown and then evaluated for detection of any defect or tearing.

A plastic cylinder was selected (1.2cm height &1.5 cm diameter) for construction of the silicone replica block. A half-scoop of Polyvinyl siloxane addition material(Express XT, putty, 3M ESPE, Germany) (orange color).was mixed with the appropriate amount of catalyst according to manufacturer's instructions and kneaded in the palm of the hand until all streaks of the catalyst had disappeared. Then it was packed immediately inside the plastic cylinder. The replicated die was embedded into un-polymerized heavy body addition silicone material till it completely polymerized the silicone replica block was marked to determine the direction of (buccal, lingual, mesial and distal). By aid of imes-icore milling machine. The silicon block was sectioned into four equal sections by cutting two central cross cuts at buccolingual and mesio distal directions. The process was repeated for all crowns in both groups.

Gap measurement: Each silicone replica was then sectioned in a bucco-palatal direction and then in a mesiodistal direction using a cutting blade in a specially designed sectioning base. The thickness of the light body silicone impression material representing the marginal and internal gaps was measured at 21 predetermined points using a digital microscope (Scope Capture Digital Stereo Microscope, Guangdong, China) at a magnification of 32x. These measuring points represent four different areas: margin, chamfer, axial, and occlusal areas[12].

For each specimen, the internal gap was measured by calculating the mean value of the chamfer, axial and occlusal area gaps. Image analyzing software (Image J, Version 1.51) which was used for the measurement of the gap width at these predetermined points determined in microns, figure 1.

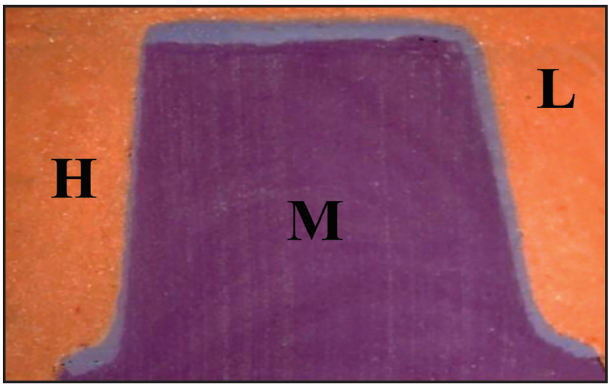

Figure (1) Digital microscopic image of sectioned replica in buccolingually direction. H: heavy orange – colored body silicone, M: medium violet – colored body silicone, L: light blue - colored body silicone.

Statistical analysis

Data were explored for normality by checking the data distribution and using Kolmogorov-Smirnov and Shapiro-Wilk tests. Independent t test was used for comparison between groups with respect to normally distributed numeric variables. Comparisons between subgroups was performed by one-way analysis of variance (ANOVA) test, followed by Bonferroni's post hoc test. All p-values are two-sided. P-values ≤0.05 were considered significant.

RESULTS

Marginal gap distance:

1- Zirconia group

In Zirconia group, the highest mean value was recorded in stone cast scan subgroup,followed by direct scan sub groupA, with the least value was recorded in impression scan subgroupB. ANOVA and post hoc test revealed that, the mean value in stone cast scan was significantly higher than the other two groups (p=0.028), (Table 1).

2. PEEK group:

In PEEK group, the highest mean value was recorded in stone cast scan subgroupC, followed by impression scanB, with the least value recorded in intraoral scan subgroupA. ANOVA and post hoc test revealed that the mean value in Stone cast scan was significantly higher than intraoral scan (p=0.04), (Table2).

Table (1) *Descriptive statistics and Comparison of marginal gap (µm) in group 1 (Zirconia).*

Marginal fit	Mean	Std. Dev	95% Confidence Interval for Mean		Min	Max	F	P
			Lower Bound	Upper Bound				
Intra-oral scan	65.66[b]	7.43	56.44	74.89	59.71	78.38		
Impression scan	63.20[b]	7.52	53.87	72.53	51.49	71.96	4.857	0.028*
Stone cast scan	90.52[a]	24.36	60.27	120.77	68.63	129.09		

*Significance level p≤0.05, *significant, ns=non-significant.*

Bonferroni post hoc test: Within the same comparison, means with different superscript letters are significantly different

Table (2) *Descriptive statistics and Comparison of marginal fit (µm)in group 2 (PEEK)*

Marginal fit	Mean	Std. Dev	95% Confidence Interval for Mean		Min	Max	F	P
			Lower Bound	Upper Bound				
Intra-oral scan	40.7[b]	7.05	31.94	49.45	31.89	49.96		
Impression scan	54.0 [a,b]	17.78	31.91	76.08	31.81	77.38	4.27	0.04*
Stone cast scan	63.43[a]	9.58	51.53	75.32	54.18	78.79		

*Significance level p≤0.05, *significant, ns=non-significant*

Bonferroni post hoc test: means with different superscript letters are significantly different

Table 3: *Comparison of Marginal Fit values of Two groups*

Subgroup	Groups	Mean	Std. Dev	Mean difference	Std error of difference	*t*	*p*
Intra-oral scan	**Zirconia** **Peek**	65.66 40.70	7.43 7.05	24.97	4.58	5.449	.001*
Impression scan	**Zirconia** **Peek**	63.20 54.00	7.52 17.78	9.21	8.63	1.066	.317 ns
Stone cast scan	**Zirconia** **Peek**	90.52 63.43	24.36 9.58	27.09	11.71	2.314	.049*

*Significance level p≤0.05, *significant, ns=non-significant*

Internal fit

Results are summarized in Table 4

Regarding subgroupA, a higher value was recorded in Zirconia group, however with no statistically significant difference between groups (p=0.222)

Regarding subgroupB, a higher value was recorded in Zirconia group, however with no statistically significant difference between groups (p=0.958)

Regarding subgroupC, a higher value was recorded in PEEK group, however with no statistically significant difference between groups (p=0.710)

Table (4) *Internal fit values of Two groups*

Subgroup	Groups	Mean	Std. Dev	Mean difference	Std error of difference	*t*	*p*
Intra-oral scan	**Zirconia** **Peek**	96.58 77.18	31.65 8.44	19.40	14.65	1.324	.222 ns
Impression scan	**Zirconia** **Peek**	101.29 100.73	10.14 20.71	.56	10.31	.055	.958 ns
Stone cast scan	**Zirconia** **Peek**	117.04 121.34	9.12 23.21	-4.30	11.15	-.386	.710 ns

Significance level p≤0.05, ns=non-significant

DISCUSSION

After the introduction of CAD/CAM system for in-office fabrication of dental prosthesis (CEREC, Sirona Dental Systems St. Paul, MN, USA), remarkable changes have led to improvements in the quality of digital scans and subsequent restorations Success of any restoration depends on accuracy of margin of restoration. Any marginal gap and improper fit lead to bacteria leakage, recurrent caries and failure of restoration [(13)].

The current study used a non-destructive impression (silicone replica technique) to measure the marginal and internal fit in all the crowns. This method duplicates the distance between the inner surface of the crowns and master model surface by measuring the thickness of light body silicon impression This method is easy and simple; it has been utilized in many studies [(5),(9)].

The results of this study showed statistically significant differences between the three scanning techniques whereas the lowest vertical marginal gap distance was recorded with zr impression scan but in PEEK group the lowest value was recorded in direct scan. This may be due to the elimination of impression and stone cast fabrication steps in case of direct scanning, leading to reduced technique sensitivity and more accurate dental prostheses with lower marginal gaps [(14,15)] So the null hypothesis for this in vitro study is rejected.

Additionally, the direct scanning technique used in this study was done on acrylic model which is easier than intraoral scanning within the patient's mouth as the operator can move the scanner freely with more accessibility without blood and saliva that could affect marginal accuracy of final restoration.

These results were in agreement with other [(16)] who reported that the direct scanning technique has the lowest marginal gap value compared to the other groups (stone cast & impression scanning). Moreover, the present results were in agreement with anther [(17)] who found that the direct scanning promotes the introduction of single-zirconia crown restorations with an adequate marginal accuracy while impression scanning led to the production of restorations with considerably higher marginal gap values.

These results were not in agreement with another study [(18)] which informed that direct scanning of stone cast resulted in fabrication of dental prostheses with higher marginal accuracy than direct scanning of the master model, this contrast might be due to the difference in the scanner type between the two studies.

Marginal accuracy of the crowns in this study were calculated by measuring the vertical gap between the margin of the preparation and that of the crowns without cementation as when the crowns are cemented, they may lose the accuracy of the primary adaptation by the influence of cement type, cement viscosity and cementation technique which might increase the marginal discrepancy. [(19)]

Marginal adaptations were measured in microns using field digital microscope. Data obtained were recorded in microns and were subjected to one- way ANOVA test.

When these results were analyzed, more gap observed for zirconia crowns may be due to increased the temperature during sintering.

According to several researches the mean marginal gap is closer to 140 μm, while others suggested a value of 50–75 μm [(20,10)]. The results of this study agree with another study which reported significantly better internal and marginal fit in PEEK crowns compared to zirconia [(21)], another study reported better internal adaptation for PEEK crowns compared to zirconia one [(22)]. This controversy could be attributed to different types of scanners, milling machines, blanks, or blocks than those used their study. Thus, the clinical acceptance of marginal gaps varies quite across studies.

The nature of selected material for crown fabrication has a significant impact on the fitting marginal gap. The results of this study were in agreement with other study [23] which found a higher marginal accuracy in PEEK crowns than zirconia crowns, this study was accomplished using direct marginal vision with stereomicroscope as well in a vivo study done.

Accuracy of PEEK and zirconia crowns was evaluated by another study [24] the results for the two materials were within the clinically acceptable rang however, PEEK yielded more accepted results compared to zirconia.

There are some limitations to this study as the study didn't include thermal cycling procedure. Thermal cycling is one of the important factors that affects the long-term marginal fit of the crown. Also all the crowns were produced and tested under ideal conditions, which may not reflect the conditions in daily clinical practice.

CONCLUSIONS

Based on the findings of this in vitro study, the following conclusions were drawn:

1. Marginal gap distance values of PEEK and zirconia crowns were within a clinically acceptable range with all types of scans.
2. Digital scanning for monolithic zirconia crowns obtained using different digital scanning methods have a higher marginal accuracy compare to PEEK crowns.
3. Intraoral scanning is the best technique and with the lowest marginal gaps.

RECOMMENDATION

Further investigation with larger samples and clinical trials needed to reinforce the results.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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REFERENCES

1. Schmeiser, F., Baumert, U., & Stawarczyk, B. Two-body wear of occlusal splint materials from subtractive computer-aided manufacturing and three-dimensional printing. Clin. Oral. Invest. 2022.26, 5857–66.
2. Akçin ET, Güncü MB, Aktas G, Aslan Y. Effect of manufacturing techniques on the marginal and internal fit of cobalt-chromium implant-supported multiunit frameworks. J. Prosthet. Dent. 2018:120:715-20.
3. Dauti R, Cvikl B, Lilaj B, Heimel P, Moritz A, Schedle A. Micro-CT evaluation of marginal and internal fit of cemented polymer infiltrated ceramic network material crowns manufactured after conventional and digital impressions. J. Prostho Dont. Res. 2018, 63: 40–6.
4. Ariganello MB, Guadarrama BD, Rodriguez-Contreras A, Sadeghi, S,Isola G, Variola F, et al . Surface nanocavitation of titanium modulates macrophage activity. Int. J. Nanomed. 2018, 13: 8297–308.
5. Praça L, Pekam FC, Rego RO, Radermacher K, Wolfart S, Marotti J. Accuracy of single crowns fabricated from ultrasound digital impressions. Dent. Mater. 2018, 34:280–8.
6. Liu Y, Fang M, Zhao R, Liu H, Li K, Tian M, Niu L, et al .Clinical applications of polyetheretherketone in removable dental prostheses: accuracy, characteristics, and performance. Polymers (Basel) 2022;14:4615.
7. Uzgur R, Ercan E, Uzgur Z, Çolak H, Yalçın M, Özcan M. Cement thickness of inlay restorations made of lithium disilicate, polymer-infiltrated ceramic and nano-ceramic CAD/CAM materials evaluated using 3d x-ray micro-computed tomography. J. Prosthet Dent. 2018, 27:456–60.
8. Pahlevaninezhad H, Khorasaninejad M, Huang YW, Shi Z, Hariri LP, Adams DC, et al. Nano-optic endoscope for high-resolution optical coherence tomography in vivo. Nat. Photonics. 2018, 12: 540.
9. Guo, J, Wu, Y, Chen, L, Long, S, Chen, D, Ouyang, H, et al. A perspective on the diagnosis of cracked tooth: imaging modalities evolve to AI-based analysis. Bio Med Engin, 2022. 21, 1-22 .
10. Asaad R S: difference in marginal and internal fitness of peek and zirconia crowns fabricated by three different impression techniques. J Egyptian Dent, 2019,65:1925

11. Praca L, Pekam FC, Rego RO, Radermarcher K ,Wolfart S, Marotti J. Accuracy of single crowns fabricated from ultrasound digital impressions. Dent Mater 2018;34:80-88

12. Al-Imam H, Benetti AR, Tomlins P, Gotfredsen K. Optical coherence tomography systems for evaluation of marginal and internal fit of ceramic reconstructions. Biomater Investig Dent. 2022 ;9:84-91.

13. Wang B, Huang M, Dang P, Xie J, Zhang X, Yan X . peek in fixed dental prostheses: application and adhesion improvement. Polymers (Basel). 2022;14:2323.

14. .Zarbakhsh A, Jalalian E, Samiei N, Mahgoli MH, Kaseb Ghane H. accuracy of digital impression taking using intraoral scanner versus the conventional technique. Front Dent. 2021;18:6.

15. Sadeqi HA, Baig MR, Al-Shammari M. Evaluation of Marginal/internal fit and fracture load of monolithic zirconia and zirconia lithium silicate (ZLS) CAD/CAM crown systems. Materials (Basel). 2021.14:6346.

16. Pedroche LO, Bernardes SR, Leão MP, Kintopp CC, Correr GM, Gonaza CC. Marginal and internal fit of zirconia copings obtained using different digital scanning methods. Braz Oral Res. 2016; 30:113.

17. Bosniac P, Rehmann P, Wostmann B. Comparison of an indirect impression scanning system and two direct intraoral scanning systems in vivo. Clin oral invest. 2019; 23.2421-27.

18. Zhang T, Wei T, Zhao Y, Jiang M, Yin X, Sun H.J . Evaluating the accuracy of three intraoral scanners using models containing different numbers of crown-prepared abutments. Dent Sci. 2022;17:204-10.

19. Renne W, McGill ST, Forshee KV, DeFee MR, Mennito AS. Predicting marginal fit of CAD/CAM crowns based on the presence or absence of common preparation errors. J Prosthet Dent. 2012; 108:310-15.

20. Amalorpavam V, Sreelal T, Chandramohan G, Jithin GN, Ponjayanthi, Kamalashankar.J comparison of marginal fit and internal adaptation of copings fabricated with polyetheretherketone and zirconia - an *in vitro* study. Pharm Bioallied Sci. 2021 :2:1199-205.

21. Ghodsi S, Alikhasi M, Sahebi M, Nazari V. marginal adaptation of implant prostheses fabricated by different materials in excessive crown height space before and after veneering. Front Dent. 2021;18:28.

22. Khamverdi Z, Najafrad E, Farhadian M. In vitro comparison of marginal and internal fit of zirconia copings fabricated by one CAD/CAM system with two different scanners. Front Dent. 2021;18:2.

23. Roy MS, Tewary S, Sanyal P. An in vivo study to compare the marginal fit accuracy of crowns prepared using two different materials. J Evolution Med Dent Sci. 2019;8:1930–4.

24. Tabesh M, Nejatidanesh F, Savabi G, Davoudi A, Savabi O, Mirmohammadi H. Marginal adaptation of zirconia complete-coverage fixed dental restorations made from digital scans or conventional impressions: a systematic review and meta-analysis. J prosthet Dent. 2021; 125, 603-10.