Original Article

HEALTH SCIENCES
MEDICINE

DOI: 10.32322/jhsm.1216516
J Health Sci Med 2023; 6(1): 116-121

Evaluation of the marginal fit of finish line designs of novel CAD/CAM restoration materials

Bike Altan, Şevki Çınar, Beste Burcu Uz, Davut Özkan

Department of Prosthodontics, Faculty of Dentistry, University of Health Sciences, İstanbul, Turkey

Cite this article as: Altan B, Çınar Ş, Uz BB, Özkan D. Evaluation of the marginal fit of finish line designs of novel CAD/CAM restoration materials. J Health Sci Med 2023; 6(1): 116-121.

ABSTRACT

Aim: The purpose of this study is to compare the marginal fit of crowns manufactured using different CAD/CAM materials on 2 different types of finish line design.

Material and Method: Tooth preparations were made by creating 2 different finish lines (rounded shoulder, chamfer) on an acrylic mandibular second premolar model. Impressions were taken on each preparation using polyvinylsiloxane impression material, and blocks with three different compositions including lithium disilicate (LDS), zirconia-reinforced lithium silicate (ZLS), and monolithic zirconia (MZ) (UP.CAD, Celtra Duo, and VITA YZ HT) were produced using a CAD/CAM (computer-aided-design and computer-aided-manufacturing) milling device (VHF R5) (n=10). The marginal gap values of the crown restorations were measured by the same operator using a stereomicroscope (LEICA DVM6). Histogram plots and the Kolmogorov-Smirnov test were used to test the normality of the distributions of the variables. The non-normally distributed (nonparametric) variables were compared using the Mann-Whitney U test for two groups and the Kruskal-Wallis test for more than two groups.

Results: The marginal gap values were compared between finish line designs separately for each material. Accordingly, the marginal gap values of the rounded shoulder finish line were smaller than those of the chamfer finish line in all materials. The marginal gap values were also compared among the materials separately for each finish line type. Accordingly, the marginal gap values of the VITA YZ HT (MZ) material were smaller than those of the Celtra Duo (ZLS) and UP.CAD (LDS) materials for both finish line designs. There was no significant difference between Celtra Duo and UP.CAD.

Conclusion: The finish line design is a factor that affects marginal fit. Monolithic zirconia is more appropriate for clinical use as it shows a better marginal fit compared to LDS and ZLS.

Keywords: Finish line, glass ceramic, CAD/CAM, marginal fit, monolithic zirconia

INTRODUCTION

Metal-free all-ceramic restorations have become more prevalently used in recent years due to their high aesthetic properties and excellent biocompatibility. The most frequently preferred all-ceramic restorations are glass ceramic, zirconia-reinforced glass ceramic, and monolithic zirconia restorations (1,2). With the help of monolithic zirconia restorations, which have been developed to eliminate the chipping problem that is seen in cases of stress in porcelains with zirconia substructures, less preparation is needed, and thinner restorations can be produced (3).

The longevity of the survival of these restorations is dependent on many factors such as aesthetics, fracture strength, and marginal fit. The achievement of an ideal marginal fit is directly associated with the finish line design to be preferred in the preparation of the tooth and the material properties of the crown that will be placed on the top (4,5).

The prognosis of the restoration is dependent on the tight fit of the fixed denture on the finish line of the prepared tooth and the minimal gap between the material and the tooth. The microleakage that will occur in cases of inadequate marginal fit will lead to a failure in the treatment by causing caries directly or leading to caries and gingivitis by causing the accumulation of plaque and food in the tooth-crown interface (6-8).

Corresponding Author: Bike Altan, bike.altan@sbu.edu.tr
Received: 08.12.2022 **Accepted:** 20.12.2022

Marginal fit can be defined as the vertical distance from the inner surface of the restoration margin to the outermost edge of the finish line of the preparation. McLean et al. (9) defined clinically acceptable marginal gaps to be in the range of 40 to 120 μm.

The finish line designs that are preferred for all-ceramic restorations are shoulder and chamfer (10-12). While the abutment margin in teeth prepared with chamfer finish line ends at a wide angle at the edge of the gingiva, there is a sharp 90° angle in those prepared with shoulder finish line. Rounded shoulder are a modification of shoulder finish line, and the marginal width in these finish lines is partially narrowed due to the rounding of the interior angle (13).

This study aimed to investigate the marginal fits of crown restorations produced out of different materials (lithium disilicate ceramic, zirconia-reinforced lithium silicate ceramic, and monolithic zirconia) to teeth prepared with different forms of finish lines (rounded shoulder and chamfer) under in-vitro conditions. The null hypothesis was determined as that the material type and finish line design do not affect the marginal fit.

MATERIAL AND METHOD

All procedures were carried out in accordance with the ethical rules and the principles. Ethics committee approval is not required as the study was not conducted on humans or animals. Sixty acrylic-based plastic mandibular second premolars (AG-3, Frasaco, Tettnang, Germany) were mounded in cold acrylic (Meliodent; Heraeus Kulzer, Hanau, Germany) up to the enamel-cement interface so that their long axes would be perpendicular to the ground plane by using plastic molds. Tooth preparations were performed by the same operator using diamond burs under water cooling to create equal numbers of preparations with rounded shoulder or chamfer finish lines (**Figure 1**). To achieve the standardization of milling amounts, using guide pin burs, 2 mm occlusal reduction was made, while an average of 1.2 mm was reduced from each of the other surfaces. Margin width of 1 mm were created around 30 of the teeth using a rounded shoulder bur with an interior angle of 90° and around the remaining 30 teeth using a conical chamfer bur with a rounded tip at a taper angle of 6°. The acrylic teeth were polished using a rotary rubber polishing tool to eliminate surface roughness. A master die was produced using polyvinylsiloxane impression material. After this, crown restorations were milled of UP.CAD (UpCera, China), Celtra Duo (Dentsply Sirona, USA), and VITA YZ HT (Vita Zahnfabrik, Germany) blocks using a CAD/CAM milling device (VHF R5, Germany). (**Figure 2**).

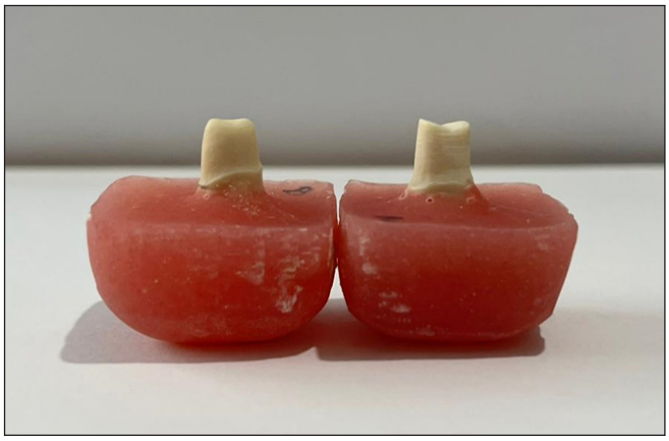

Figure 1. Chamfer and rounded shoulder finish line designs.

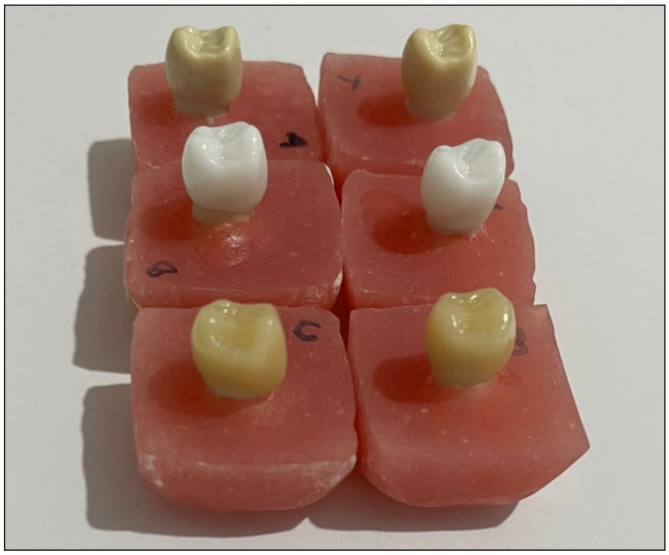

Figure 2. Crown restorations with different materials used in this study.

Standardization was established by measuring the thicknesses of the restorations using a digital caliper. The crowns that were produced were placed onto the prepared teeth, and the vertical distance from the inner surface of the restoration margin to the outermost edge of the finish line of the preparation was examined using a stereomicroscope (Leica microsystems, model DVM6, Germany) at X47 magnification (**Figure 3**). The measurements were carried out by the same operator from 4 points (buccal, palatal, mesial, and distal) (**Figure 4**).

Statistical Analysis

The statistical analyses were performed using the SPSS v.25.0 program. The normal distribution of the variables was tested based on histogram plots and the Kolmogorov-Smirnov test. Descriptive statistics were calculated and are presented as mean, standard deviation, median, and min-max values. The non-normally distributed (nonparametric) variables were compared using the Mann-Whitney U test for two groups and the Kruskal-Wallis test for more than two groups. In all analyses, $p<0.05$ was considered statistically significant.

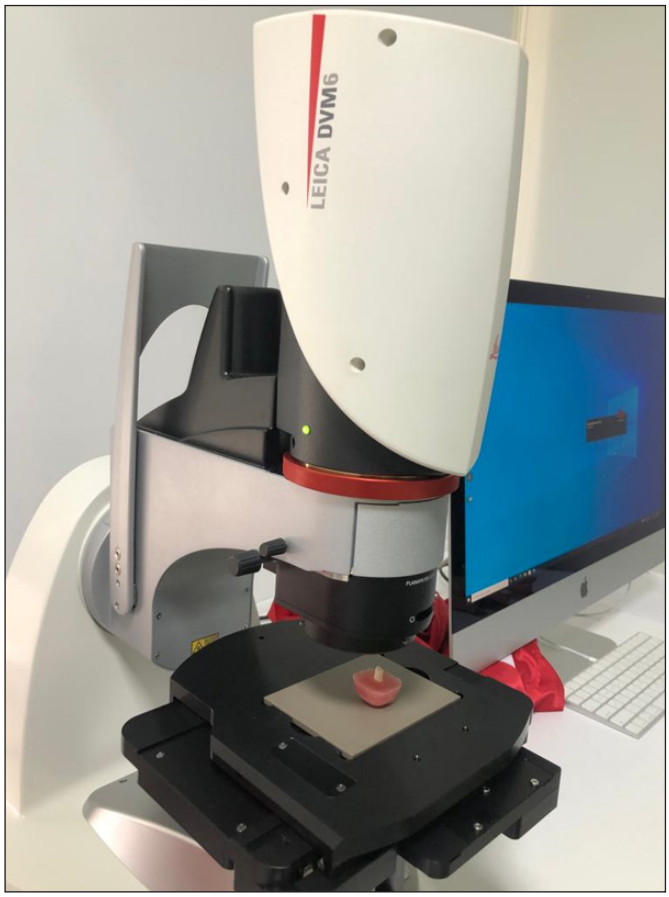

Figure 3. Specimen under stereomicroscope.

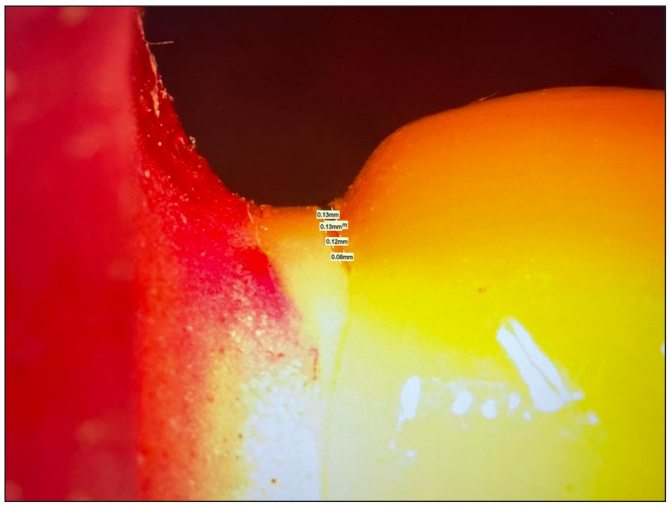

Figure 4. Marginal gap measurement under stereomicroscope.

RESULTS

The mean marginal gap values, standard deviations, median and min-max values for each group are presented in **Table 1**. It displays that the marginal gap values of the MZ material were smaller significantly than those of the ZLS and LDS materials while there was no significant difference between the ZLS and LDS. Additionally, the marginal gap values of the rounder shoulder finish line were smaller than those of the chamfer finish line. **Figure 5** and **6** show that comparisons of marginal fit among the materials and finish line designs.

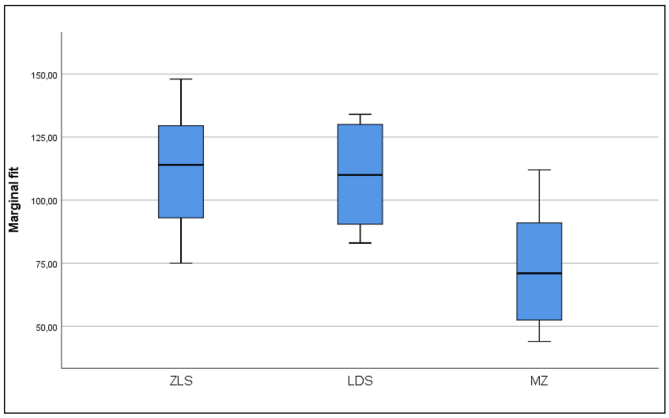

Figure 5. Comparison of marginal fit between materials.

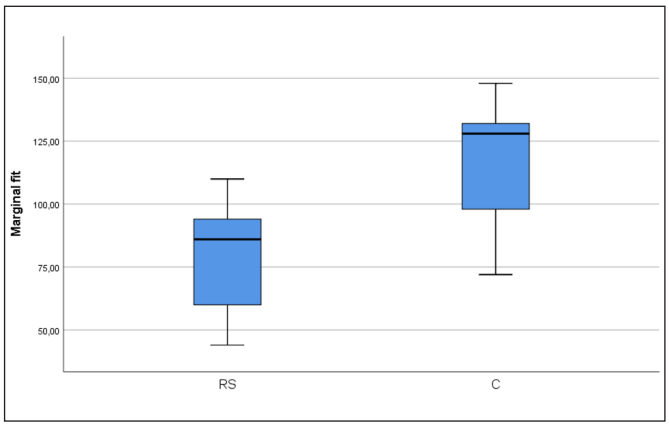

Figure 6. Comparison of marginal fit between finish line designs.

Table 1. Comparison marginal gap values between the materials and finish line design.

	Mean±SD	Median (Min-Max)	p
Material			<0.001[1]
ZLS	111.65±22.97	114 (75-148)	
LDS	110.1±20.69	110 (83-134)	
MZ	72.55±21.38	71 (44-112)	
Finish line			<0.001[2]
RS	78.67±19.31	86 (44-110)	
C	117.53±21.16	128 (72-148)	

[1]Kruskal-Wallis Test [2]Mann-Whitney U Test

Table 2 displays that the comparisons of marginal gap values between the finish line types separately for each material. According to **Table 2**, the marginal gap values of the rounded shoulder were smaller than those of the chamfer in all materials. The marginal gap values were also compared among the materials separately for each finish line. Accordingly, the marginal gap values of the MZ material were smaller than those of the ZLS and LDS materials for both finish line designs. However, there was no significant difference between ZLS and LDS for finish line types. **Figure 7** shows distribution of the marginal gap values of the materials according to the finish line designs while **Figure 8** shows the distribution of marginal gap values of finish line according to materials.

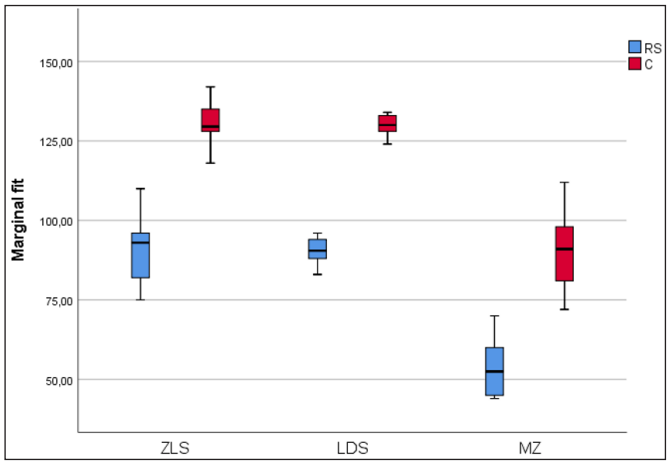

Figure 7. Distribution of the marginal gap values of the materials according to the finish line designs.

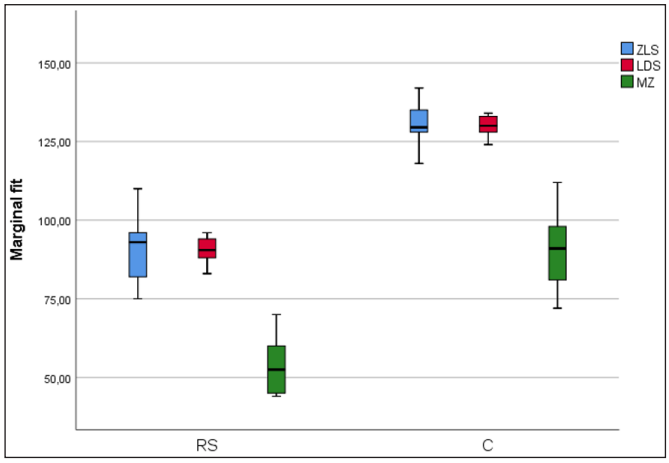

Figure 8. Distribution of marginal gap values of finish line according to materials.

Table 2. Comparison of marginal gap values between finish line types for each material.

	Finish line				p[1]
	RS		C		
	Mean±SD	Median (Min-Max)	Mean±SD	Median (Min-Max)	
Material					<0.001
ZLS	91.2±10.70	93 (75-110)	132.1±8.37	129.5 (118-148)	
LDS	90.3±4.45	90.5 (83-96)	129.9±3.51	130 (124-134)	<0.001
MZ	54.5±9.64	52.5 (44-70)	90.6±12.17	91 (72-112)	<0.001
p[1]	<0.001		<0.001		

[1]Kruskal-Wallis Test [2]Mann-Whitney U Test

DISCUSSION

The long-term survival of restorations is closely related to their marginal fit. There are several factors that affect the marginal fit such as finish line design (4,14,15), abutment design (16,17), impression techniques (18,19,20), CAD/CAM systems (4,21,22), sintering time (23), type of material (5,25,26), cement space (26) and cementation (27,28). The literature review that was conducted for this study did not show any study on the marginal fit values of monolithic zirconia, lithium disilicate, and zirconia-reinforced lithium silicate ceramic crowns on teeth prepared with different finish line designs. In this study, the effects of different finish line designs and different materials on marginal fit were investigated, and consequently, the null hypothesis was rejected.

While preparing teeth, abutments can be prepared with finish line designs such as the shoulder, rounder shoulder, and chamfer designs. While there are studies in the relevant literature that have concluded that different finish lines have an effect on marginal fit (15,29), there are also those that have stated the opposite (30,31). These differences can be attributed to the differences in methods of analyzing marginal fit, the production technique of restorations or the restoration material itself. In this study, independently of the materials, the marginal gap values of the crowns with rounded shoulder finish lines were smaller than those of the crowns with chamfer finish lines. The results of present study were in agreement with Euan et al. (4)' study.

The accuracy and dimensional stability of impressions taken from prepared teeth are important. For a fixed denture to be placed onto the existing tooth to have the ideal properties, an identical model of the preparation in the intraoral environment should be created in the laboratory environment. Impressions can be taken using digital methods (intraoral scanners) and conventional methods. Nevertheless, in the literature, there is no consensus on the superiority of both impression techniques to one another. More studies are needed to accurately evaluate the reliability, accuracy, repeatability, and scanning durations of intraoral scanners (32).

Previous studies have examined the marginal fit properties of restorations in cemented (33) or uncemented (19,23,29) forms. Because problems in cementation techniques such as disproportionate finger pressure or the overfilling of the crown with cement lead to loss of marginal fit, in this study, the marginal gap measurements were made before cementing (34).

In general, there is no definite evidence on the best methodology to assess the marginal fit accuracy of CAD/CAM crowns. In previous studies, marginal gap values have been measured using various devices including optical microscopes (15,22) scanning electron microscopes (SEM) (18,33) and stereomicroscopes (29,34). No statistically significant difference has been reported between these methods (35,36). A marginal fit measurement that is made using SEM may require cementation or the cutting of cemented crowns, which may lead to irreversible damage to the master die and limit the number and positions of measurements (37). Although marginal fit measurements can be made without cementing by micro-CT, it would be challenging to maintain a uniform pressure on the crown during measurements. For these reasons, a stereomicroscope was preferred in this study.

The marginal gap values obtained in different studies differ from each other. There is also an agreement among different researchers that marginal gap values smaller than 120 µm are clinically acceptable (9, 38). In studies in the relevant literature, the marginal gap values of zirconia crowns have been reported in the range of 36.56 to 70.94 µm (39,40) while the values of lithium disilicate crown restorations have been reported between 61.86 and 103.75 µm (40,41). Previous studies have shown smaller marginal gaps in zirconia material than in lithium disilicate material (35). On the other hand, Mohaghegh et al. (42) reported that monolithic zirconia crowns had better marginal fit values than zirconia crowns.

In the study where they investigated the post-cementing marginal fit values of conventional zirconia (Katana zirconia) and lithium disilicate (IPS e.max CAD) crowns by micro-CT, Riccitiello et al. (43) reported marginal gap values of 63 µm in zirconia crowns and 65 µm in lithium disilicate crowns. In our study, in the chamfer finish line measurements, the marginal gap values were found as 90.6±12.17 µm for monolithic zirconia (VITA YZ HT) and 129.9±3.51 µm for lithium disilicate (UP. CAD). The differences in the marginal gap values reported in previous studies and those in present study may be explained by the use of a stereomicroscope as the measurement instrument in our study and the fact that measurements was made before cementing.

In current study, while there was no statistically significant difference between the marginal gap values of the lithium disilicate (LDS) and zirconia-reinforced lithium silicate (ZLS) crowns, the marginal fit values of the monolithic zirconia crowns were found significantly superior to those of the LDS and ZLS crowns. Batson et al. (44) compared the marginal fit values of monolithic zirconia, lithium disilicate, and metal-ceramic restorations and concluded that the best fit was in the monolithic zirconia restorations.

In the study in which they compared the marginal fit values of lithium disilicate and hybrid ceramic CAD/CAM crowns, Azarbal et al. (45) found the mean marginal gap values of the lithium disilicate crowns as 132.25 µm. In present study, the marginal gap value of the lithium disilicate crowns was measured as 90.3 µm. This difference may have been caused by the abutment designs, finish line designs, and differences in milling systems.

A limitation of this study was the fact that the marginal fit of restorations was investigated only in second premolar teeth. Another limitation may be the fact that no thermal aging treatment was applied in our study. In future studies, thermal aging treatments can be performed to investigate whether the marginal fit of crown restorations is influenced by intraoral conditions such as saliva and humidity.

CONCLUSION

1. Clinically acceptable marginal gap values were obtained in all material groups prepared using rounded shoulder abutments.
2. Monolithic zirconia showed better marginal fit values compared to the LDS and ZLS materials in both finish line designs.
3. There was no significant difference between the LDS and ZLS materials in terms of marginal fit.

ETHICAL DECLARATIONS

Ethics Committee Approval: Ethics committee approval is not required as the study was not conducted on humans or animals.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. Aziz A, El-Mowafy O, Paredes S. Clinical outcomes of lithium disilicate glass-ceramic crowns fabricated with CAD/CAM technology: A systematic review. Dent Med Probl 2020; 57: 197–206.
2. Zarone F, Ruggiero G, Leone R, Breschi L, Leuci S, Sorrentino R. Zirconia-reinforced lithium silicate (ZLS) mechanical and biological properties: A literature review. J Dent 2021; 109: 103661.
3. Church TD, Jessup JP, Guillory VL, Vandewalle KS. Translucency and strength of high-translucency monolithic zirconium oxide materials. Gen Dent 2017; 65: 48–52.
4. Euán R, Figueras-Álvarez O, Cabratosa-Termes J, Oliver-Parra R. Marginal adaptation of zirconium dioxide copings: influence of the CAD/CAM system and the finish line design." J Prosthet Dent 2014; 112: 155-62.
5. Sakrana, AA. In vitro evaluation of the marginal and internal discrepancies of different esthetic restorations. Journal of Applied Oral Science, 2013; 21: 575–580.
6. Jacobs MS, Windeler AS. An investigation of dental luting cement solubility as a function of the marginal gap. J Prosthet Dent 1991; 65: 436–42
7. Goldman M, Laosonthorn P, White RR. Microleakage-Full crowns and the dental pulp. J. Endod. 1992; 18: 473–75
8. Sailer I, Fehér, A, Filser F, et al. Prospective clinical study of zirconia posterior fixed partial dentures: 3-year follow-up. Quintessence Int 2006; 37: 685–93
9. McLean JW, Von F. The estimation of cement film thickness by an in vivo technique. Br. Dent. J. 1971; 131: 107–11
10. Goodacre CJ, Campagni WV, Aquilino SA. Tooth preparations for complete crowns an art form based on scientific principles. J Prosthet Dent 2001; 85:363-76
11. Quintas AF, Oliveira F, Bottino MA. Vertical marginal discrepancy of ceramic copings with different ceramic materials, finish lines, and luting agents: an in vitro evaluation. J Prosthet Dent 2004; 92: 250-7.

12. Holmes JR, Bayne SC, Holland GA, Sulik WD. Considerations in measurement of marginal fit. J Prosthet Dent 1989; 62: 405-8.
13. Shillingburg HT, Hobo S, Whitsett LD, Brackett SE. Fundamentals of fixed prosthodontics. Third Edition, .(1997) Quintessence Publishing Co. Inc., London.
14. Vojdani M, Safari A, Mohaghegh M, Pardis S, Mahdavi F. The effect of porcelain firing and type of finish line on the marginal fit of zirconia copings. J Dentistry (Shiraz) 2015; 16: 113–20.
15. Re D, Cerutti F, Augusti G, Cerutti A, Augusti D. Comparison of marginal fit of Lava CAD/CAM crown-copings with two finish lines. Int J Esthet Dent 2014; 9: 426-35.
16. Boitelle P, Tapie L, Mawussi B, Fromentin O. Evaluation of the marginal fit of CAD-CAM zirconia copings: Comparison of 2D and 3D measurement methods. J Prosthet Dent 2018; 119: 75–81.
17. Alghazzawi TF, Al-Samadani KH, Lemons J et al. Effect of imaging powder and CAD/CAM stone types on the marginal gap of zirconia crowns. J Am Dent Assoc 2015; 146: 111–20.
18. Yus EA, Cantarell JMA, Alonso AM. Comparison of the marginal fit of milled yttrium stabilized zirconium dioxide crowns obtained by scanning silicone impressions and by scanning stone replicas. J Advanced Prosthodontics 2018; 10: 236–44.
19. Dahl BE, Dahl JE, Ronold HJ. Digital evaluation of marginal and internal fit of single-crown fixed dental prostheses. Eur J Oral Sci 2018; 126: 512–7.
20. Kocaagaoglu H, Kilinc, HI, Albayrak H. Effect of digital impressions and production protocols on the adaptation of zirconia copings. J Prosthet Dent 2017; 117: 102–8.
21. Ji MK, Park, JH, Park SW, Yun KD, Oh GJ, Lim HP. Evaluation of marginal fit of 2 CAD-CAM anatomic contour zirconia crown systems and lithium disilicate glass-ceramic crown. J Advanced Prosthodontics 2015; 7: 271–7.
22. Lins L, Bemfica V, Queiroz C, Canabarro A. In vitro evaluation of the internal and marginal misfit of CAD/CAM zirconia copings. The Journal of Prosthetic Dentistry, 2015; 113: 205–11.
23. Khaledi AAR, Vojdani, M, Farzin M, Pirouzi S, Orandi S. The effect of sintering time on the marginal fit of zirconia copings. J Prosthodontics 2019; 28: 285–9.
24. Schriwer C, Skjold A, Gjerdet NR, Oilo M. Monolithic zirconia dental crowns. Internal fit, margin quality, fracture mode and load at fracture. Dental Materials 2017; 33: 1012–20.
25. Hamza TA, Ezzat HA, El-Hossary MM., Katamish HA, Shokry TE, Rosenstiel SF. Accuracy of ceramic restorations made with two CAD/CAM systems. J Prosthetic Dentistry 2013; 109: 83–7.
26. Kale E, Seker E, Yilmaz B, Ozcelik, T.B. Effect of cement space on the marginal fit of CAD-CAM-fabricated monolithic zirconia crowns. J Prosthet Dent 2016; 116: 890–5.
27. Sener I, Turker B, Valandro, LF, Ozcan, M. Marginal gap, cement thickness, and microleakage of 2 zirconia crown systems luted with glass ionomer and MDP-based cements. General Dentistry 2014; 62: 67–70.
28. Pilo R, Folkman M, Arieli A, Levartovsky, S. Marginal fit and retention strength of zirconia crowns cemented by self-adhesive resin cements. Operative Dentistry 2018; 43: 151–61
29. Ahmed WM, Shariati B, Gazzaz AZ, Sayed ME, Carvalho RM. Fit of tooth-supported zirconia single crowns-A systematic review of the literature. Clin Exp Dent Res 2020; 6: 700-16.
30. Tsitrou EA, Northeast SE, van Noort R. Evaluation of the marginal fit of three margin designs of resin composite crowns using CAD/CAM. J Dent 2007; 35: 68-73.
31. Akbar JH, Omar R, Al-Tarakmah Y. Marginal Integrity of CAD/CAM Ceramic crowns using two different finish line designs. Medical Principles and Practice 2021; 443 - 47.
32. Khraishi H, Duane B. Evidence for use of intraoral scanners under clinical conditions for obtaining full-arch digital impressions is insufficient. Evid Based Dent 2017; 18: 24-5.
33. Ortega R, Gonzalo E, Gomez-Polo M, Lopez-Suarez C, Suarez MJ. SEM evaluation of the precision of fit of CAD/CAM zirconia and metal-ceramic posterior crowns. Dent Mater J 2017; 36: 387-93.
34. Pilo R, Cardash, HS. In vivo retrospective study of cement thickness under crowns. J Prosthet Dent 1998; 79: 621-25.
35. Baig MR, Al-Tarakemah Y, Kasim NHA, Omar R. Evaluation of the marginal fit of a CAD/CAM zirconia-based ceramic crown system. Int J Prosthodon 2022; 35: 319–29.
36. Groten M, Girthofer S, Pröbster L. Marginal fit consistency of copy- milled all ceramic crowns during fabrication by light and scanning electron microscopic analysis in vitro. J Oral Rehabil 1997; 24: 871-88.
37. Memari Y, Mohajerfar M, Armin A, Kamalian F, Rezayani V, Beyabanaki E. Marginal Adaptation of CAD/CAM All-Ceramic Crowns Made by Different Impression Methods: A Literature Review. J Prosthodont 2018: 1-9
38. Suárez MJ, González de Villaumbrosia P, Pradíes G, Lozano JF. Comparison of the marginal fit of Procera AllCeram crowns with two finish lines. Int J Prosthodont. 2003;16: 229-32.
39. Comlekoglu M, Dundar M, Ozcan M, Gungor M, Gokce B, Artunc C. Influence of cervical finish line type on the marginal adaptation of zirconia ceramic crowns. Oper Dent 2009; 34: 586-92
40. Fuzzi M, Tricarico MG, Ferrari Cagidiaco E, Bonadeo G, Sorrentino R, Ferrari M. Nanoleakage and internal adaptation of zirconia and lithium disilicate single crowns with feather edge preparation. J Osseointegr 2017; 9: 250-62.
41. Kim JH, Jeong JH, Lee JH, Cho HW. Fit of lithium disilicate crowns fabricated from conventional and digital impressions assessed with micro-CT. J Prosthet Dent 2016; 116: 551-7.
42. Mohaghegh M, Firouzmandi M, Ansarifard E, Ramazani L. Marginal fit of full contour monolithic zirconia in different thicknesses and layered zirconia crowns. J Int Soc Prevent Communit Dent 2020; 10: 652-8.
43. Riccitiello F, Amato M, Leone R, Spagnuolo G, Sorrentino R. In vitro Evaluation of the marginal fit and internal adaptation of zirconia and lithium disilicate single crowns: Micro-CT comparison between different manufacturing procedures. Open Dent J 2018; 12: 160-72.
44. Batson ER, Cooper LF, Duqum I, Mendonça G. Clinical outcomes of three different crown systems with CAD/CAM technology. J Prosthet Dent 2014; 112: 770-7.
45. Azarbal A, Azarbal M, Engelmeier RL, Kunkel TC. Marginal Fit Comparison of CAD/CAM Crowns Milled from Two Different Materials. J Prosthodont 2018; 27: 421-8.