EGYPTIAN DENTAL JOURNAL
www.eda-egypt.org
VOL. 70, 3437:3449, OCTOBER, 2024
PRINT ISSN 0070-9484 • ONLINE ISSN 2090-2360
FIXED PROSTHODONTICS AND DENTAL MATERIALS
Submit Date : 09-06-2024 • Accept Date : 07-07-2024 • Available online: 05-10-2024 • DOI : 10.21608/EDJ.2024.296508.3076

EFFECT OF OCCLUSAL CEMENT SPACE ON THE MARGINAL AND INTERNAL FIT OF VERTIPREP ZIRCONIA AND HYBRID CERAMIC CROWNS. AN IN-VITRO STUDY

Omnia Nabil * *and* Alaa El-Ashkar **

ABSTRACT

Statement of problem. Occlusal cement space thickness (OST) affects the marginal and internal fit of ceramic crown. However, the recommendations for vertiprep OST settings for ceramic crowns are limited.

Purpose. The purpose of this study was to evaluate the marginal and internal fit of zirconia and hybrid ceramic crowns restoring verti-preped premolars, designed with different OST.

Materials and Methods. Upper premolar typodont was prepared with an edgeless finish line. A standardized crown design with 70µm axial cement space thickness was created using EXOCAD software. 40 crowns were grouped: Groups Z50 and Z70 for monolithic zirconia crowns with 50µm and 70µm OST respectively, and Groups En50 and En70 for hybrid ceramic crowns with the same OST settings (n = 10). All crowns were produced following manufacturers' instructions. Vertical marginal gap (VMG) and internal gap (IG) were assessed using direct viewing and silicone replica techniques respectively, under a stereomicroscope. Statistical analysis included one-way ANOVA followed by Tukey's post-hoc test for group and site comparisons ($P \leq 0.05$).

Results. En70 showed the lowest VMG values, followed by En50, Z70, and Z50. Z70 showed the lowest IG values, followed by Z50, En50 and En70. The occlusal surface exhibited the highest internal gap values in all groups, while the cervical area showed the least values.

Conclusions. The OST and the ceramic crown material had a significant effect on the marginal and internal fit of the final crown. The recommended OST for zirconia crowns is 70 µm, whereas for hybrid ceramic crowns, 50 µm is preferred.

KEYWORDS. Vertical preparation, Occlusal cement space thickness, ceramic crown, Vertical marginal gap, Internalgap

* Lecturer, Department of Fixed Prosthodontics, Faculty of Dentistry, Cairo University
** Assistant Professor of Prosthetic Dentistry Department, Faculty of Dentistry, King Salman International University

INTRODUCTION

Recent restorative concepts are mainly based on conservative approaches [1]. Not only these concepts are applied to intraenamel preparation designs, but also, they include cases requiring full coverage crowns. During classic tooth preparations to receive full coverage restorations, removal of sound tooth at the cervical area to create horizontal finish line is sometimes inevitable to ensure structural durability and enhance marginal integrity of ceramic restorations. [2,3]

However, vertical preparations which are also known as feather edge preparations has been gaining popularity recently as one of the minimal invasive concepts. They were primarily indicated in periodontally compromised teeth, vital teeth in young patients and sometimes in malaligned teeth. [4]

Additionally, they could be utilized for any teeth to conserve sound tooth structure and extend the finish area subgingivally for better retention and masking the crown margin. [5]

The introduction of ceramic materials with high mechanical properties, improved adhesive protocols as well as continuous progress in CAD/CAM technology aided in applying the minimal invasive concepts with predictable outcome taking into consideration not to compromise marginal integrity of the final restoration. [6-9]

Zirconia based ceramics were basically introduced as bilayered restorations to achieve optimum mechanical properties with favorable esthetic outcomes. However, many studies investigating failure modes in veneered zirconia restorations revealed that fractures often occur in veneer layer [10]. As a consequence, monolithic designs being more conservative were introduced to overcome complications of bilayered restorations. [11]

Besides, the enhanced optical properties of recent monolithic zirconia formulations as in ultra-translucent and multilayered zirconia as well as maintaining their superior mechanical strength in milled thin sections made them a great option in modern restorative dentistry. [12]

Another category of ceramic materials showed expanding interest in the dental market are hybrid ceramics, also known as resin-matrix-ceramics, resin-based ceramics or nanoceramics. This can be attributed to their mechanical stability, high elasticity, superior bonding strength to tooth structure, as well as their compatibility with chairside production making them an innovation in modern clinical workflows specially dealing with the minimal invasive cases. [13,14]

Marginal and internal accuracy are crucial factors in the success of fixed restorations satisfying biologic, mechanical and esthetic requirements. Many factors might influence marginal and internal fit including finish line design, thickness, convergence angle, cement space thickness, restoration material and fabrication method. However, former studies showed controversial results regarding the effect of definite finish line design on the marginal accuracy[15-18]. Others found that knife edge margins achieved superior marginal fit. [19,20]

Regarding the cement space thickness; Nakamura et al. [21] investigated the marginal and internal fit of CAD/CAM all ceramic crowns, with different convergence angles and cement space settings. They found that the internal gap was significantly affected by the cement space. On the other hand, Iwai et al. [22] found that the different cement spaces did not have any significant effect on the marginal discrepancy of the tested zirconia copings.

Since data regarding the influence of occlusal spacer setting on the marginal and internal fit of Zirconia and Hybrid Ceramic Crowns constructed on vertiprep abutments is still rare, thus this study was conducted to fill the knowledge gap discussing this point.

The first null hypothesis was that the occlusal cement space thickness would have no significant effect on the marginal fit values of the vertiprep zirconia and hybrid ceramic crowns, while the second null hypothesis was that occlusal cement space thickness would have no significant effect on the internal gap values of the vertiprep zirconia and hybrid ceramic crowns.

MATERIALS AND METHODS

A sample size of 40 crowns was determined using software (PS Power and Sample Size Calculations Version 3), based on a significance level of 0.05 and a power of 0.8, as established by previous research by Fouad M. [23] The tested groups were categorized according to the material type: Group Z monolithic zirconia and Group En Vita Enamic hybrid ceramic. Subdivisions within each group (n=10) were based on the occlusal cement space thickness (OST), namely Z50 (monolithic zirconia with 50μm OST), Z70 (monolithic zirconia with 70μm OST), En50 (Vita Enamic hybrid ceramic with 50μm OST), and En70 (Vita Enamic hybrid ceramic with 70μm OST).

Upper right second premolar (NISSIN Dental Model, Koyoto, Japan) was prepared to receive a full coverage restoration with edgeless and equigingival finish line. A depth cutter (PrepMarker;Komet Dental) was utilized to create a 1.5 mm occlusal guiding groove, followed by a tapered stone with a round end diamond rotary instrument (medium-grit; Komet Dental) to reduce the occlusal surface in a planar manner. Subsequently, the surface was refined with a similar fine-grit instrument (Komet Dental). Horizontal grooves were placed on the axial surfaces using a depth cut (PrepMarker; Komet Dental) to guide 1 mm of axial reduction. The total occlusal convergence was adjusted at 12°. [24,25]

Edgeless vertiprep cervically was then achieved using medium and fine grit Batt burs (Komet Dental). A silicone index was used to verify the amount of reduction between each step. The preparation was further polished using finishing disks (Sof-Lex Finishing and Polishing System; 3M ESPE) and rubber wheels (Eve Diacomp plus occluflex) and was checked for inadequacies by the same investigator (O.N.) using magnifying loops (Designs for Vision, Inc).

The preparation was scanned using an intraoral scanner (Primescan, Dentsply Sirona), and the images were transferred to design software (Exocad 3.0 GALWAY, GmbH). A single design for monolithic anatomical crowns was applied to all experimental groups, and a standardized axial cement space thickness of 70um with 0.5mm margin free space was set for all crowns. Only the occlusal cement space varied between 50um and 70um. During fabrication, the crowns were milled based on their respective materials. For groups Z50 and Z70, a 5-axis milling machine (DWX-52D, Roland DG Corporation Hamamatsu) operated in dry milling mode to produce monolithic zirconia crowns (Katana STML, Kuraray Noritake Dental Inc), followed by sintering (inFire HTC speed furnace, Sirona). Using wet grinding mode, a 4-axis milling machine (Cerec MCXL, Dentsply Sirona) was employed for groups En50 and En70 to produce hybrid ceramic crowns (Vita Enamic, VITA Zahnfabrik, Bad Säckingen). Subsequently, all crowns underwent polishing using their respective polishing kits (EVE Ernst Vetter GmbH, VITA Zahnfabrik, Bad Säckingen) in a two-step process following manufacturer instructions. The crowns were then inspected for imperfections (O.N) before being sealed in opaque envelopes, which were randomly numbered using an online software (www.random.org).

For assessment of the vertical marginal gaps with direct viewing, each crown was secured on the typodont by using a custom holding device. Measurements were made with a stereomicroscope (Leica S8 APO) at 25X magnification. Five equidistant landmarks were measured along the cervical circumference of each of the mesial, buccal, distal, and lingual surfaces. **(Fig. 1)**

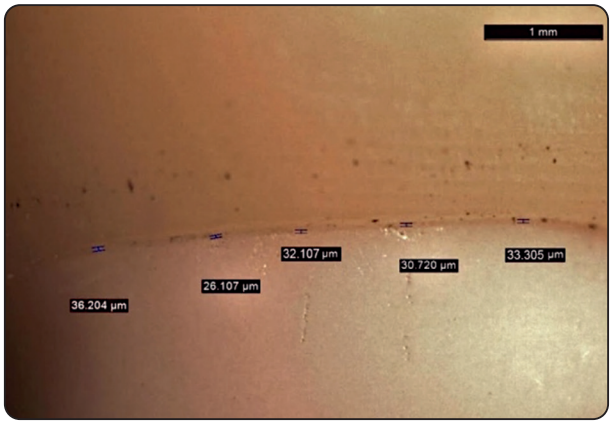

Fig. (1) Vertical marginal gap values at 5 points on the distal surface of Z50 crown at 25X magnification.

Two samples from the En group exhibited no visible gaps when examined under a Stereomicroscope ranging from 25X to 40X magnification. Subsequently, a validation test was carried out: employing a scanning electron microscope (SEM; Model Quanta 250 Field Emission Gun; FEI Company, The Netherlands) at 1000X magnification, which confirmed the absence of measurable vertical gaps on both the mesial and distal surfaces of these two En crowns. **(Fig. 2)** Both En samples were part of this study; however, the results of the validation methods were not included in the results.

Fig. (2) SEM image at 1000X showing the complete adaptation of En70 crown margins on the typodont tooth.

Following this, a qualitative assessment of crown margins immediately after milling was conducted, once again utilizing a Stereomicroscope (Leica S8 APO) at 40X magnification. **(Fig. 3, 4)**

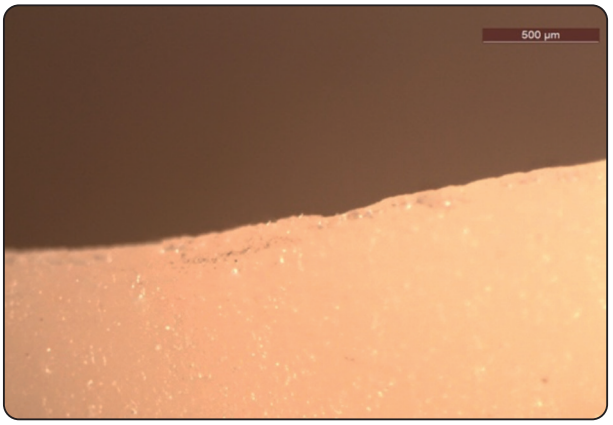

Fig. (3) The edge of zirconia crown showing areas of chipping at 40X magnification.

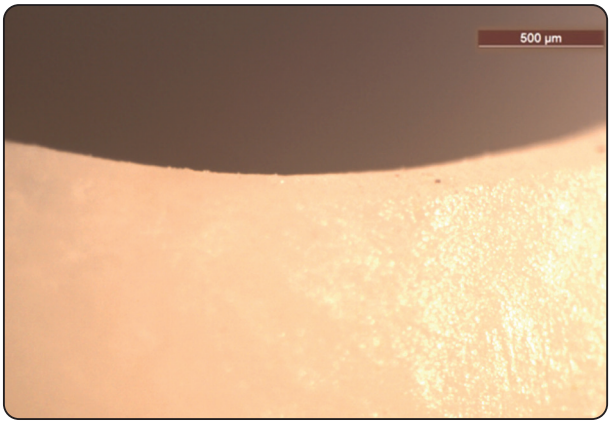

Fig. (4) The edge of hybrid ceramic crown showing smooth continuous margin without chipping at 40X magnification.

The internal adaptation was assessed using the silicone replica technique. Intaglio replicas were created using light-body and putty silicone impression material (GC FLEXCEED Addition silicone, GC Corporation). These replicas were divided into 4 equal segments in both the mesiodistal and buccolingual directions. Measurements were conducted with a Stereomicroscope (Leica S8 APO) at 25X magnification, focusing on various landmarks. Seven points within 3 regions were measured on each section: 2 cervical points, 2 axial points, and 3 occlusal points located at the occlusoaxial line angle, mid-occlusal, and occlusal fossa. **(Fig. 5)**

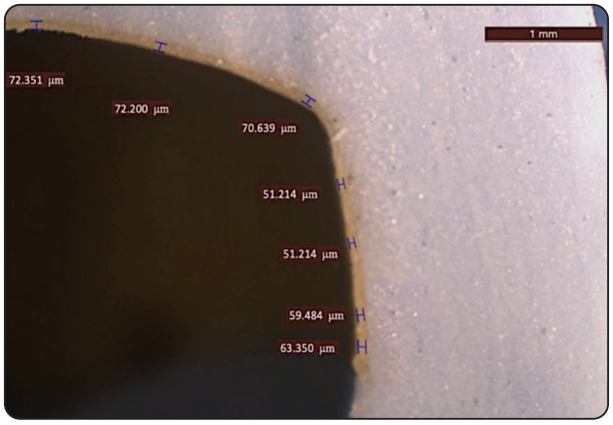

Fig. (5) Internal gap measurements at 7 points of Z70 crown at 25X magnification.

All data were gathered, evaluated, tabulated, and subjected to statistical analysis using statistical software programs (SPSS 20®, Graph Pad Prism®, and Microsoft Excel 2016). Exploration of the given data was performed using Shapiro-Wilk test and Kolmogorov-Smirnov test for normality which revealed that data originated from normal data distribution in all groups The statistical analysis utilized the average of all measured points. The data were presented as minimum, maximum, mean, and standard deviation in a one-way ANOVA test, followed by Tukey's Post Hoc test for multiple comparisons (group and site). ($P \leq 0.05$).

RESULTS

In terms of vertical marginal gap, a significant disparity was observed among all groups (P<0.0001) across all surfaces. En70 displayed the lowest mean value (6.03±0.10 μm), while Z50 recorded the highest mean value (22.82±1.41 μm). **(Table 1, Fig. 6)**

Significant variations were observed among different surfaces within each group. In the Z50 group, the mesial surface exhibited the lowest marginal discrepancy values (13.66±1.97μm), whereas the distal surface showed the highest values (32.155±1.82μm). Z70 group, the buccal (10.403±0.7 μm) and lingual surfaces (10.05±0.95μm) displayed the lowest values with no significant difference between them, while the distal surface demonstrated the highest values (13.47±0.73μm). For the En50 group, the mesial surface had the lowest values (3.67±0.34μm), whereas the buccal surface recorded the highest values (23.67±1.33 μm). Similarly, En70 group, the mesial surface exhibited the lowest values (3.22±0.22μm), while the buccal surface showed the highest values (9.23±0.28 μm).

TABLE (1) Vertical marginal gap of all groups at different surfaces and comparison between them using One Way ANOVA test:

Vertical marginal gap	Z50		Z70		En50		En70		P value
	M (μm)	SD	M (μm)	SD	M (μm)	SD	M (μm)	SD	
Buccal	22.458 aA	1.57	10.403 aB	0.70	23.676 aC	1.33	9.234 aD	0.28	<0.0001**
Mesial	13.665 bA	1.97	11.48 bB	1.12	3.678 bC	0.34	3.225 bD	0.22	<0.0001**
Distal	32.155 cA	1.82	13.47 cB	0.73	8.092 cC	0.57	3.602 cD	0.20	<0.0001**
Lingual	23.036 aA	2.19	10.05 aB	0.95	14.122 dC	0.42	8.083 dD	0.08	<0.0001**
Overall	22.829A	1.41	11.35 B	0.49	12.394 C	0.39	6.037 D	0.10	<0.0001**
P value	<0.0001**		<0.0001**		<0.0001**		<0.0001**		

M: mean SD: standard deviation **Highly significant difference as P<0.001.
Means with different superscript letters (Small per column / capital per raw) were significantly different as P<0.05.
Means with the same superscript letters (Small per column / capital per raw) were insignificantly different as P>0.05.

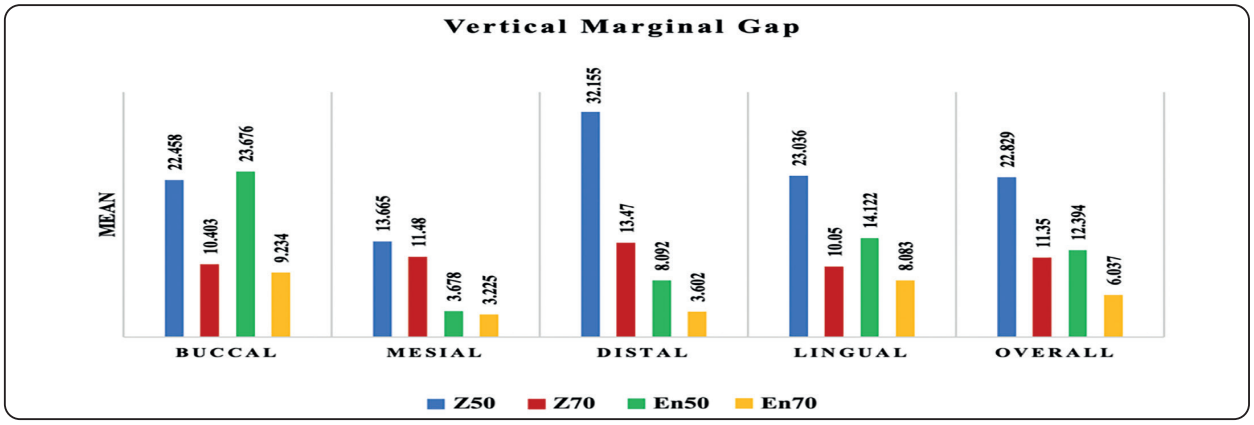

Fig. (6) Column chart representing vertical marginal gap values in μm at all surfaces of all groups.

Significant differences were observed in internal adaptation across all groups, with En70 displaying the highest internal gap mean value (184.05±5.77μm), and En50 showing the lowest internal gap mean value (66.728±4.02 μm). **(Table 2, Fig. 7)**

Within each group, significant differences were noted among different surfaces. The cervical area had the lowest internal gap values, followed by the axial surface, and finally the occlusal surface had the highest values.

Table (2). Internal gap of all groups at different surfaces and comparison between them using One Way ANOVA test:

Internal fit	Z50		Z70		En50		En70		P value
	M (μm)	SD	M (μm)	SD	M (μm)	SD	M (μm)	SD	
Cervical	48.93 aA	4.08	56.36 aB	3.67	29.69 aC	5.27	66.37 aD	9.26	<0.0001*
Axial	81.91 bA	9.71	63.14 bB	7.87	96.39 bC	8.07	113.86 bD	9.98	<0.0001*
Occlusal	108.00 cA	4.54	80.68 cB	5.86	315.16 cC	16.12	371.93 cD	12.33	<0.0001*
Overall	79.61 A	2.73	66.728 B	4.02	147.08 C	6.47	184.05D	5.77	<0.0001*
P value	<0.0001**		<0.0001**		<0.0001**		<0.0001**		

M: mean SD: standard deviation **Highly significant difference as P<0.001.
Means with different superscript letters (Small per column / capital per raw) were significantly different as P<0.05.
Means with the same superscript letters (Small per column / capital per raw) were insignificantly different as P>0.05.

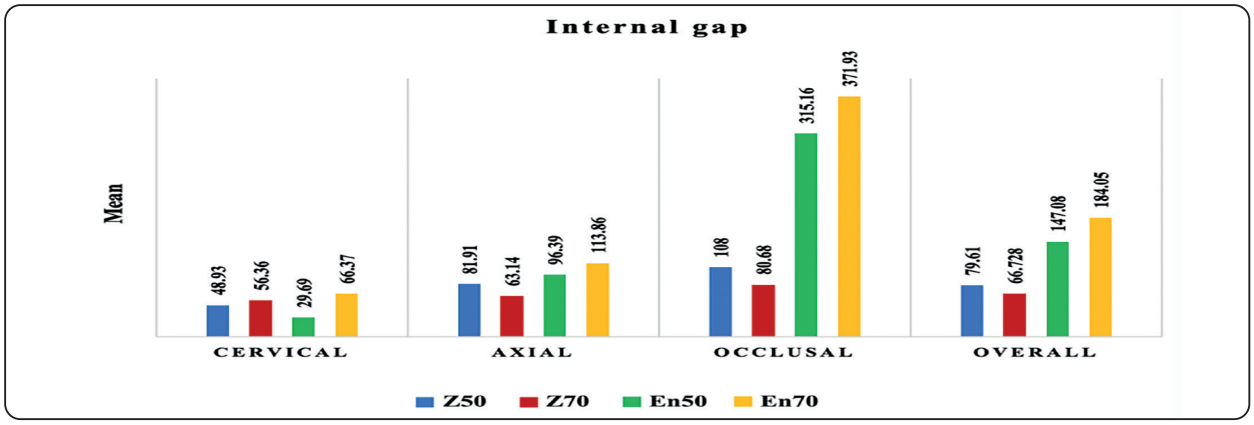

Fig. (7) Column chart representing internal gap values in μm at all surfaces of all groups.

DISCUSSION

Tooth preparation is mandatory for full coverage restorations. It is an irreversible approach that needs to be performed with great care to preserve the maximum amount of tooth structure. For years, horizontal finish line has been considered the most reliable and definite preparation type, however, in the last few years vertical finish line preparation has gained popularity as a conservative design for full coverage crowns.[26]

Vertical preparation with edgeless finish line (Vertiprep) was chosen in this study. It is uprising as a viable preparation method for the full coverage crown that enhances the esthetic results and aids in the thickening and the stability of the surrounding soft tissue.[27] Vertiprep has been indicated as an applicable treatment for periodontally compromised abutments. Also, it is considered reliable upon restoring endodontically treated teeth, and cervically carious vital teeth.[28] The conservative advantage of this preparation is preserving as much tooth structure cervically as possible and distancing the preparation from the pulp limiting the possibility of pulpal irritation especially in young aged patients.[29]

Dental ceramic materials have been upgrading greatly. Advances in their composition and CAD/CAM technology have contributed to the production of wide variety of materials with the aim of achieving the optimum esthetic, mechanical and biological properties of restorations.[30]

Two ceramic materials that belong to different families were selected in this study. The first material was monolithic zirconia material which belongs to the polycrystalline ceramic family and has proven its reliability in fixed prosthodontics owing to its biocompatibility and high mechanical properties. Furthermore, the translucent zirconia types have remarkably enhanced the esthetic properties. The high flexural strength of zirconia allowed for the production of high strength crowns with thin occlusal and radial thickness.[13,31] The second selected material was hybrid ceramic which belongs to the resin-matrix ceramic family. This material combines the advantageous qualities of both ceramics and composites. It has enamel and dentine like mechanical properties with proper resilience. Its fracture toughness and ease of machining allowed for the promising results of delivering restorations with thin margins.[13,28]

Marginal and internal adaptation of crowns are key elements for the success of restorations clinically. The decrease in the gaps at the margins and internally could improve the resistance of the final restorations to leakage and caries through diminishing the dissolution of cement.[32] Cement space has a direct correlation with the marginal fit of tooth-supported CAD/CAM crowns, where the

marginal fit decreases when the cement space is increased. However, the increase in cement space must not exceed 120 μm to avoid the accompanying inner misfit together with the shrinkage of cement due to polymerization which eventually leads to the decrease in the resistance of ceramic crowns to failure.[33,34]

Today, when fabricating CAD/CAM restorations, the cement space thickness is adjusted in the designing software both radially and occlusally. The influence of this parameter on the marginal and internal adaptation of full coverage restorations has been addressed in several studies[34-36] however, they all dealt with the occlusal and axial spacers as one entity Ibrahim et al [37]. Evaluated the effect of modifying the occlusal cement spacer and found that this modification had significantly affected zirconia crown adaptation where better internal fit of zirconia crowns has been recorded with the reduced occlusal cement space.

This idea has been earlier introduced in 2013 by Saber et al.[38] where they evaluated the internal fit of cemented casted metal copings on a die covered with die spacer axially only without adding any material to the occlusal surface. They concluded that this approach improved the coping seating in the occlusal surface. Moreover, they added that increasing cement space occlusally resulted in the presence of excess cement occlusally hindering the complete seating of restoration.

Thus, in this study 2 occlusal cement space thicknesses have been compared. The first one was set at 70μm[39,40], while in the other group, the occlusal cement space thickness had been reduced to 50 μm which has been advocated by Grajower and Lewinstein [41] to be the least acceptable to provide 30 µm space for the cement and 20µm space to overcome any production error.

In this study, one premolar had been conservatively prepared for vertiprep and used for the CAD/CAM production of all crowns, thus standardizing the produced crowns.[42]

Vertical marginal gap (VMG) measurement is considered the most common marginal accuracy assessment measurement. Unlike horizontal discrepancies, vertical discrepancies are the least likely to be corrected after crown fabrication.[43] Adjustments of crown overhangs as an example of horizontal discrepancies can be done to some extent, however vertical discrepancies can only be dealt with using luting cement, which is later subjected to dissolution. Accordingly, VMG measurement is considered the most valuable in marginal gap evaluation of crowns.[35]

In the current study, direct viewing method was used to assess the marginal fit of the crowns using stereomicroscope. This method is the most commonly followed reproducible approach, also it is categorized as non-invasive and time saving.[44] A total of 20 measurements were recorded per crown to achieve the least number of readings necessary to report clinically relevant information about the size of the marginal gap.[45]

To measure the internal gap between the crown and the tooth, crown cementation was simulated with light consistency of polyvinylsiloxane material through the well-known replica technique.[46] The silicon replica is a reliable non-destructive technique that is easy to apply, accurate, and reproducible.[47]

According to the results of the present study in terms of vertical marginal gap (VMG), the first null hypothesis was rejected since the occlusal cement space thickness had statistically significant effect on the marginal fit values of the vertiprep zirconia and hybrid ceramic crowns.

All the tested crowns' marginal gap results were far below the range of the maximally accepted value of marginal gaps for dental restorations which was stated by Demir et al.[48] to be 50-120µm. The highest mean VMG was recorded by Z50 (22.82μm ±1.41) and the least was recorded by En70 (6.03± 0.10 µm).

The better results of En crowns could be attributed to their combined hybrid nature of ceramic

network and resinous network, thus acquiring the advantages of fast milling with longer lifespan of the milling burs and high post milling edge stability. [49]

The qualitative observation of the margins of hybrid ceramics after milling carried out in this study showed that these margins were obviously smooth and continuous without chipping which was in agreement with Awada et al.[50]. These results supported the capability of hybrid ceramics to adapt properly to conservative minimal preparations especially at the margins.

This material has the ability to attain its physical properties immediately after milling without shrinkage or deformation as it does not require any post milling heat treatment. It was stated that heat treatment for sintering/crystallization or even glazing might cause adverse effects on the marginal accuracy. [26]

Hybrid ceramics have greater resilience when compared to ceramics. [51] This advantage allows the restoration to be seated easily with less strain Dabbousi et al. [52] Stated that the longer the length of curvature of the finish line vertically on the axial wall, the higher the adaptation of the hybrid ceramic crown.

Salem SK and Asaad RS [26] compared posterior Vita Enamic hybrid ceramic crowns to Ceramill Zolid zirconia ones with vertical finish line preparation. They found that the hybrid ceramic group showed lower insignificant mean marginal gap than zirconia group. This difference than the current study could be attributed to their use of a different zirconia material.

The reduction of the occlusal cement space thickness had an inverse relationship to the vertical marginal gap in both tested materials. This could be explained by the observed overseating phenomenon, where the absence of horizontal finish line stop allowed the crown to bypass the vertiprep finish line. The reduction of the occlusal cement space thickness acted as a horizontal occlusal stop to restrict the movement of the crown beyond the vertiprep finish line and thus, Z50 and En50 had higher vertical marginal gaps when compared to their corresponding Z70 and En70 crowns.

The variation in the VMG values among surfaces of crowns was evident. For En50, En70 and Z50 groups, the mesial surface recorded the lowest values; while in Z70, the buccal and lingual surfaces displayed the lowest values. On the other hand, En50 and En70 had the highest values at the buccal surface, while Z50 and Z70 had the highest values at the distal surface. These results might be related to the difference in composition and properties of the tested ceramic materials. Also, the applied milling protocols in this study might have been influential, where the zirconia crowns were produced by 5-axis machine using dry milling mode, and the hybrid ceramic crowns were produced by 4-axis machine using wet grinding mode. Finally, milling the restorations directly at thin margins could be greatly affected by the milling tools and the edge stability of the ceramic material.

The second null hypothesis was also rejected since the occlusal cement space thickness had statistically significant effect on the internal fit of the vertiprep zirconia and hybrid ceramic crowns.

Significant differences were observed among all groups in terms of the overall internal gap (IG) values, with Z70 exhibited the lowest mean value (66.728±4.02 μm) and En70 displayed the highest one (184.05±5.77μm).

All the recorded crowns' internal gap (IG) at the cervical area (closest to the margin) ranged between (29.69±5.27μm) and (66.37±9.26μm) in the following order En70 > Z70 > Z50 > En50. These values were in the range of maximum accepted value for the marginal gap. [48]

Regarding the IG at the axial wall, the recorded values ranged between (63.14±7.87μm) and (113.86±9.98 μm) in the following order En70 > Z50 > Z70 > En 50. There was obvious increase in the axial values as compared to the cervical

ones. The study of Tuntiprawon and Wilson [53] is considered the reference regarding setting 122 μm as the maximum acceptable cement thickness at the axial wall to avoid the decrease in the resistance of ceramic crown to fracture. Accordingly, all groups were within the clinically acceptable limit.

In addition, in all the tested groups the increase in the IG values had continued on to the occlusal surface where the IG values ranged between (80.68±5.86 μm) and (371.93±12.33 μm) in the following order En70 > En50 > Z50 > Z70.

Refaie et al [40] mentioned in their study that the reported accepted occlusal gap ranges between 250 and 300μm. Only Z50 and Z70 groups recorded values below this range, while the En50 and En70 groups recorded higher values (315.16±16.12μm) and (371.93±12.33 μm) respectively.

In all groups, the recorded internal gap values were higher than the cement space thickness set in the CAD/CAM software highlighting the negative impact of the replica cementation like procedure on the seating of the restorations. [54]

The results showed that the produced crowns in both groups had non uniform internal fit values along the occlusal, axial, and cervical tooth surfaces, despite setting an even cement space thickness along axial and cervical surfaces in groups Z50 and En50 and along all surfaces in groups Z70 and En70. This could be attributed to factors like scanner accuracy, conversion of files to STL format, or the dimensions of the internal bur in the milling machine and milling mode. To minimize these potential errors, a standardized die scanning method was adopted: employing a single scan and design for crown fabrication to reduce scanning discrepancies and eliminate variables associated with file conversion. [55]

In addition to that the observed inverse relationship of the occlusal and the cervical internal gaps could be explained by the fact that the better the marginal fit, the less is the ability of the light body polyvinyl siloxane or the cement to escape and thus it accumulates in the occlusal surface with hydraulic pressure buildup. [54] This is exacerbated by the viscoelastic rheological changes of the light polyvinyl siloxane material. [56]

Rustum et al. [57] concluded in their study that increasing the cement space thickness during designing is considered beneficial and produces high marginal fit. This conclusion supports the results of zirconia groups, where Z70 showed better marginal and internal fit than Z50, while in Enamic groups, En70 showed better marginal fit but less internal fit than En50. Based on these findings, there is an influence of the type of ceramic material on the internal fit of the final restoration.

The results of this study disagreed with Yadav et al. [55] who found a direct correlation between the marginal and internal fit where hybrid ceramic crowns had better marginal and internal fit than zirconia crowns. However, it has to be noted that they used heavy chamfer and shoulder horizontal finish lines which could be the reason behind the difference between their results and this study.

Vertiprep design of premolars could be successfully restored with monolithic zirconia and hybrid ceramic crowns. Upon evaluating the crowns' margins directly, there was significant differences in favor of 70μm occlusal cement space thickness in both materials with hybrid ceramic surpassing zirconia in producing crowns with better marginal fit, however, all results were below 25μm. The recognized overseating phenomenon justified the recorded small vertical marginal gap mean values and accordingly we could not rely solely on the vertical marginal gap values to evaluate the fit. The replica technique was necessary to simulate the process of cementation and provide clinically relevant results. The combined effect of the type of the ceramic material and the occlusal cement space thickness was significant on the internal fit of the final restoration. For zirconia crowns, 70μm occlusal cement space thickness yielded better fit, while for hybrid ceramic crowns, 50μm occlusal cement space thickness yielded better fit.

In the current study, carrying out the measurements of the marginal and internal fit without cementation is considered a limitation as there is a difference in the physical properties of the cement and the light body polyvinyl siloxane used in this study, besides the possible flaws of silicone replica technique could influence the fit of the crowns. Another limitation is producing the crowns using two milling machines (4-axis and 5-axis). The added axis of the 5-axis milling machine aids in the production of more accurate restorations with better surface details and finishing. However, the choice of milling machine for each material was determined primarily by its ability to deliver the most optimal restoration fit values. [58]

CONCLUSIONS

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

1. Occlusal cement space thickness had a significant effect on marginal and internal fit of zirconia and hybrid ceramic crowns.
2. The type of the ceramic material had a significant effect on the marginal and internal fit of the final restoration.
3. For premolars with vertiprep, the recommended occlusal cement space for monolithic zirconia crowns is 70 μm, whereas for hybrid ceramic crowns, it is advised to maintain a space of 50μm for better internal fit.

REFERENCES

1. Tyas MJ, Anusavice KI, Frencken JE, Mount GJ: Minimal intervention dentistry; a review. FDI Commission project 1-97. Int Dent J. 2000 Feb;50(1):1-12.
2. Contrepois M, Soenen A, Bartala M, Laviole O: Marginal adaptation of ceramic crowns: a systematic review. J Prosthet Dent. 2013 Dec;110(6):447-54.
3. Zarone F, Russo S, Sorrentino R: From porcelain-fused-tometal to zirconia: clinical and experimental considerations. Dent Mater. 2011 Jan;27(1):83-96.
4. Cagidiaco EF, Discepoli N, Goracci C, Carboncini F, Vigolo P and Ferrari M.:(2019): 'Randomized Clinical Trial on Single Zirconia Crowns with Feather-Edge vs Chamfer Finish Lines: Four-Year Results'. Int J Periodont Restorat Dent.;39(6):817-826.
5. G. No`e, A. Toffoli, E. Foce, G. Di Febo, G. Carnevale, R. Bonfiglioli, et al., Vertical edgeless preparation: periodontal dominance in prosthetic crown preparation, Prosthesis 5 (2023) 358–367
6. Beuer F, Aggastaller H, Edelhoff D, Gernet W, Sorenson J: Marginal and internal fits of fixed dental prostheses zirconia retainers. Dent Mater. 2009 Feb;25:94-102.
7. Bindl A, Mormann WH. Marginal and internal fit of allceramic CAD/CAM crown copings on chamfer preparations: J Oral Rehabil. 2005 Jun;32(6):441-47.
8. 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 Sep-Oct;34(5):586-92.
9. Poggio CE, Dosoli R, Ercoli C: A retrospective analysis of 102 zirconia single crowns with knife-edge margins. J Prosthet Dent. 2012 May;107(5):316-21.
10. Taskonak B, Borges GA, Mecholsky JJ Jr, et al: The effects of viscoelastic parameters on residual stress development in a zirconia/glass bilayer dental ceramic. Dent Mater 2008; 24:1149-1155
11. Rauch A, Reich S, Schierz O: Chair-side generated posterior monolithic lithium disilicate crowns: clinical survival after 6 years. Clin Oral Investig 2017;21:2083-2089
12. Kontonasaki, E., Rigos, A. E., Ilia, C. and Istantsos, T.:(2019) : Monolithic Zirconia: An Update to Current Knowledge. Optical Properties, Wear, and Clinical Performance'. Dent. J.
13. Gracis, S.; Thompson, V.P.; Ferencz, J.L.; Silva, N.R.; Bonfante, E.A. A new classification system for all-ceramic and ceramic-like restorative materials. Int. J. Prosthodont. 2015, 28, 227–235
14. Aslan, Y.U.; Coskun, E.; Ozkan, Y.; Dard, M. Clinical evaluation of three types of CAD/CAM inlay/onlay materials after 1-Year clinical follow up. Eur. J. Prosthodont. Restor. Dent. 2019, 27, 131–140.
15. Guess PC, Zavanelli RA, Silva NR, Bonfante EA, Coelho PG, Thompson VP. Monolithic CAD/CAM lithium disilicate versus veneered Y-TZP crowns: comparison of

failure modes and reliability after fatigue. Int J Prosthodont 2010;23:434-42.

16. Raigrodski AJ, Hillstead MB, Meng GK, Chung KH. Survival and complications of zirconia-based fixed dental prostheses: a systematic review. J Prosthet Dent 2012;107:170-7.
17. Jiang L, Liao Y, Wan Q, Li W. Effects of sintering temperature and particle size on the translucency of zirconium dioxide dental ceramic. J Mater Sci Mater Med 2011;22:2429-35.
18. Baig MR, Tan KB, Nicholls JI. Evaluation of the marginal fit of a zirconia ceramic computer-aided machined (CAM) crown system. J Prosthet Dent 2010;104:216-27.
19. Rosenstiel SF, Land MF, Fujimoto J. Contemporary fixed prosthodontics. 5th ed. St. Louis: Elsevier; 2016. p. 167-440.
20. Rinke S, Fornefett D, Gersdorff N, Lange K, Roediger M. Multifactorial analysis of the impact of different manufacturing processes on the marginal fit of zirconia copings. Dent Mater J 2012;31:601-9
21. Goldman M, Laosonthorn P, White RR. Microleakage e full crowns and the dental pulp. J Endod 1982;18:473-5.
22. Valderhaug J, Heloe LA. Oral hygiene in a group of supervised patients with fixed prostheses. J Periodontol 1977;48:221-4.
23. Fouad, M. Marginal adaptation related to margin design of CAD/CAM ceramic crowns. Egyptian Dental Journal, 2023; 69(1): 447-455.
24. Goodacre, C. J., Campagni, W. V., & Aquilino, S. A. Tooth preparations for complete crowns: An art form based on scientific principles: J. Prosthet. Dent. 2001; 85(4), 363–376.
25. Beuer, F., Edelhoff, D., Gernet, W., & Naumann, M. Effect of preparation angles on the precision of zirconia crown copings fabricated by CAD/CAM system: Dent. Mater. J. 2008; 27(6), 814–820.
26. Salem, S.K, Asaad, R.S. Marginal Integrity of Different CAD/CAM Monolithic Ceramic Crowns with Vertical and Horizontal Finish Line Preparations. Egyptian Dental Journal, 2024; 70(2): 1761-1759.
27. Kaur H, Singhtomar S, Dhawan P. Vertical Preparation: Biologically Oriented Preparation Technique (BOPT). Journal of Pierre Fauchard Academy (India Section). 2022; 36(1): 1-7
28. EL-Mashali, I., Wahsh, M., Zohdy, M. The Effect of two margin designs on fracture resistance of Zirconia re-enforced lithium silicate crowns. Ain Shams Dental Journal, 2023; 29(1): 23-31.
29. Cortellini D, Canale A. Bonding lithium disilicate ceramic to featheredge tooth preparations: a minimally invasive treatment concept. J Adhes Dent. 2012; 14:7-10.
30. Shenoy A, Shenoy N. Dental ceramics: An update. J Conserv Dent. 2010 Oct;13(4):195-203.
31. Abdulazeez, M. I., & Majeed, M. A.: Fracture Strength of Monolithic Zirconia Crowns with Modified Vertical Preparation: A Comparative In Vitro Study.: Eur. J. Dent,2021
32. Mously HA, Finkelman M, Zandparsa R, Hirayama H. Marginal and internal adaptation of ceramic crown restorations fabricated with CAD/CAM technology and the heat-press technique. J Prosthet Dent. 2014 Aug;112(2):249-56.
33. Hegazy, M., Shakal, M., El Sharkawy, S., Sultan, S. Effect of Cement Space Settings on the Vertical Marginal gap of Cement Retained - Implant Supported Crowns: An in vitro study. Advanced Dental Journal, 2022; 4(2): 110-122.
34. Kale E, Seker E, Yilmaz B, Özcelik TB. Effect of cement space on the marginal fit of CAD-CAM-fabricated monolithic zirconia crowns. The Journal of Prosthetic Dentistry. 2016; 116 (6): 890-895.
35. Eldamaty, M., Abdel-Aziz, M., El-kouedi, A., and Hamza, T.A. Effect of finish line design and cement space thickness on the marginal accuracy of monolithic zirconia crowns. Brazilian dental science.2020; 23(3)
36. Ben-Izhack, G.; Shely, A.; Naishlos, S.; Glikman, A.; Frishman, L.; Meirowitz, A.; Dolev, E. The Influence of Three Different Digital Cement Spacers on the Marginal Gap Adaptation of Zirconia-Reinforced Lithium Silicate Crowns Fabricated by CAD-CAM System. Appl. Sci. 2021, 11, 10709.
37. Ibrahim H, El Kateb M, Morsy N. Effect of modifying occlusal cement spacer on the fit accuracy of digitally manufactured zirconia crowns. J Prosthet Dent. 2024 Jan;131(1):93.e1-93.e6
38. Saber FS, Abolfazli N, Mahboub F, Razavi FE. The effect of occlusal surface relief of dies on marginal adaptation of metal-ceramic casting copings. J Prosthodont. 2013 Jun;22(4):287-91.
39. Nakamura K, Mouhat M, Nergård JM, Lægreid SJ, Kanno T, Milleding P, Örtengren U. Effect of cements on fracture resistance of monolithic zirconia crowns. Acta Biomater Odontol Scand. 2016;2(1):12–19.

40. Refaie A, Fouda A, Bourauel C, Singer L. Marginal gap and internal fit of 3D printed versus milled monolithic zirconia crowns. BMC Oral Health. 2023 Jul 4;23(1):448.

41. Grajower R, Lewinstein I. A mathematical treatise on the fit of crown castings. J Prosthet Dent 1983;49:663–74.

42. Hany C., Taymour M. Marginal Chipping Of Three Different CAD/CAM Ceramic Veneering Materials As Influenced By Machinability. Egyptian Dental Journal, 2020; 66(1)– January.

43. Holmes, J. R., Bayne, S.C., Holland, G.A. & Sulik, W.D.:(1989): Considerations in measurement of marginal fit.', J Prosthet Dent., 62(4), pp. 405–8.

44. Nawafleh, N. A., Mack, F., Evans, J., Mackay, J. & Hatamleh, M.M. :(2013): Accuracy and reliability of methods to measure marginal adaptation of crowns and FDPs: a literature review.', J Prosthodont., 22(5), pp. 419–28.

45. Groten, M., Axmann, D., Pröbster, L., & Weber, H. :(2000): Determination of the minimum number of marginal gap measurements required for practical in vitro testing', J Prosthet Dent., 83(1), pp. 40–49.

46. Praça L, Pekam F. C, Rego R. O, Radermacher K, Wolfart S, Marotti J. Accuracy of single crowns fabricated from ultrasound digital impressions, Dental Materials. 2018; 34 (11): e280-e288.

47. El-Farag SAA, Elerian FA, Elsherbiny AA, Abbas MH. Impact of different CAD/CAM materials on internal and marginal adaptations and fracture resistance of endocrown restorations with: 3D finite element analysis. BMC Oral Health. 2023 Jun 25;23(1):421.

48. 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 Oct;8(4):437-444.

49. Azarbal A, Azarbal M, Engelmeier RL, Kunkel TC. Marginal Fit Comparison of CAD/CAM Crowns Milled from Two Different Materials. J Prosthodont. 2018 Jun; 27(5):421-428.

50. Awada A, Nathanson D. Mechanical properties of resin-ceramic CAD/CAM restorative materials. J Prosthet Dent 2015;114:587-93.

51. Qian K, Yang X, Feng H, Liu Y. Marginal adaptation of different hybrid ceramic inlays after thermal cycling. Advances in Applied Ceramics. 2020 Jul;119(5-6):284-90.

52. Dabbousi AM, Ibrahim RM, Sherif RM. Influence of Finish Line Design on the Vertical Marginal Discrepancy of Enamic Hybrid Ceramic: In vitro Study. Egyptian Dental Journal. 2016 Jan 1;62(1-January (Part 2)):571-6.

53. Tuntiprawon, M.; Wilson, P.R. The effect of cement thickness on the fracture strength of all-ceramic crowns. Aust. Dent. J. 1995, 40, 17–21.

54. Habib SR, Ali M, Al Hossan A, Majeed-Saidan A, Al Qahtani M. Effect of cementation, cement type and vent holes on fit of zirconia copings. Saudi Dent J. 2019 Jan;31(1): 45-51.

55. Yadav P, Sharma V, Paliwal J, Meena KK, Madaan R, Gurjar B. An In Vitro Comparison of Zirconia and Hybrid Ceramic Crowns With Heavy Chamfer and Shoulder Finish Lines. Cureus. 2023 Jan 18;15(1):e33940.

56. El-Ashkar A, Nabil O, Taymour M, El-Tannir A. Evaluation of zirconia crowns restoring endodontically treated posterior teeth with 2 finish line designs and 2 occlusal reduction schemes: A randomized clinical trial. J Prosthet Dent. 2022 Nov 14: S0022-3913(22)00634-5.

57. Rustum M, Gonzalez MAG, Kasim A, Hayaty N, Abu Kassim NL, Farook MS. Effect of operators' experience and cement space on the marginal fit of an in-office digitally produced monolithic ceramic crown system. Quintessence Int 2016; 47:181-91.

58. Pilecco RO, Machry RV, Baldi A, Tribst JPM, Sarkis-Onofre R, Valandro LF, Kleverlaan CJ, Scotti N, Pereira GKR. Influence of CAD-CAM milling strategies on the outcome of indirect restorations: A scoping review. J Prosthet Dent. 2024; 131(5): 811.e1-811.e10. doi.org/10.1016/j.prosdent.2024.02.021.