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EFFECT OF MARGIN DESIGNS AND PORCELAIN VENEERING ON ACCURACY OF BI LAYERED ZIRCONIA CROWN

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ABSTRACT

Statement of problem: Degree of marginal discrepancy determines effectively success and failure of fixed restorations.

Purpose: To evaluate the effect of porcelain veneering techniques on the marginal fit of bi- layered zirconia crown using four marginal designs.

Materials and Methods: A 40 Plaster replicas were made from two master dies and divided into two main groups (20 for each) according to type of finish line. Each group subdivided into two subgroups (10 for each) to obtain the following groups {A1} shoulder without cervical collar {A2} shoulder with 1 mm cervical collar. {B1} chamfer without cervical collar {B2} chamfer with 1 mm cervical collar. Zirconia blanks were milled using CAD/CAM system to produce 40 zirconia copings. Then, Veneering of the copings was done. Vertical gap distances were measured at 18 predetermined points.

Results: Veneering with porcelain exhibited statistical significant difference in mean values of marginal gap in both group {A1} and {B1}, while veneering with porcelain did not exhibit significant difference in both group {A2} and {B2} in comparison with the pre veneering state. Correlations based on the finish line design exhibited significant difference in mean values of marginal gap between all tested groups. Correlations based on presence or absence of cervical zirconia collar did not exhibited statistical significant difference between tested groups. On other hand, there were significant differences in mean values of marginal gap between tested groups in post veneering state, at the level of P value < 0.05.

Conclusions: Marginal fit of the final crowns with chamfer finish lines were better than that with shoulder, however, veneering with porcelain significantly raised marginal gap distance of crowns with collarless shoulder and chamfer preparations, while in that designs with cervical collar, veneering was not significantly affected on the marginal gap distance for both finish line designs

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INTRODUCTION

Recently, significant improvement in all ceramic materials, their reasonable esthetic outcome, biocompatibility and improved strength enable wide use of esthetic restoration not only anteriorly for esthetic purpose, but also in posterior region. [1] Where Zirconium oxide possess a superior mechanical and physical properties with high strength (*900-1150 mpa*) and fracture toughness (*6.2-7.4 mpa × m−0.5*) Place it in consideration during selection of core material for metal free restorations. [2]

Consequent to the widespread use of Computer Aided Design (CAD) & Computer Aided Manufacturing (CAM) techniques, zirconia based prostheses have been introduced as a suitable alternative solution for the esthetic drawbacks of conventional metal ceramic restorations. [3,4] But, at the same time, the clinical behavior of bi-layered zirconia restorations (veneered) exhibited marginal fit drawbacks, where, it is not only depend on the material strength but also on their coping marginal designs and veneering porcelain relationship. Marginal gap is the distance between the finish line of the preparation and the cervical margin of the restoration [5]. A good marginal fit is one of the most important long success factors for any fixed restoration, since discrepancies at the crown margin favor plaque accumulation, with great liability to caries recurrence and periodontal affection.[6] Previously, there were numerous studies that have been done to evaluate the marginal accuracy of bi layered zirconia with different designs of finish lines like shoulder [7,8], chamfer [9-14] or both [15-18], but without taking cervical zirconia collar in their considerations.

Several studies have reported the marginal gap distance for all-ceramic restorations with different techniques (castable glass ceramics, slip casting, heat pressing and machining) which range from 17 to 172 μm. [25-26] But, in some of these studies, the effect of cervical zirconia collar was not evaluated because they assumed that it will not cause any significant changes in the marginal integrity of all ceramic restorations. [27] Taking the previous studies in consideration, the purpose of this in vitro study was directed to evaluate the effect of porcelain veneering on the marginal fit of bi layered zirconia crown using four marginal designs

MATERIALS AND METHODS

A two master metal dies were designed and milled using lath to be simulated a single molar full coverage metal free crown preparation with standardized dimensions; 6.5 mm in height, 6 degrees of axial wall convergence and 1.0 mm-wide margin (according to the clinical guideline of manufacturer [28] with a uniform deep chamfer finish line for one of them and shoulder for the other). V - shaped groove (2 mm length and 0.5 mm depth) was made in the axial wall parallel to the long axis for proper seating of the coping on the master metal die and to prevent their rotation during measurement steps Figure (1). At 20 ° intervals, 18 points that have been taken as a measurement references were marked on a line 2 mm below the margin by means of a high speed hand-piece and a diamond needle bur. [29] Then, a starting point was marked. A 40 Plaster replicas were made from the master dies using double impression technique with an addition silicone (*OBELIS S.A, Brussels, Belgium*) of two consistencies (putty soft and light body), (For each preparation type, 20 impressions were taken). Then the plaster replicas were coded and divided into two main groups according to finish line type (20 for each) then each group subdivided into two subgroups (10 for each to obtain the following groups {A 1} shoulder finish line without cervical collar, {A 2} shoulder finish line with 1 mm cervical collar, {B 1} chamfer finish line without cervical collar and {B 2} chamfer finish line with 1 mm cervical collar Figure (2). [31]

Stone dies were scanned using Cercon eye (*Cercon Smart Ceramic System, DeguDent, Germany*), zirconia blanks (Y-TZP) were milled according to manufacturer instructions using Cercon Brain to produce 40 zirconia copings with wall thickness 0.4

mm and margin thickness 0.3 mm [28] (10 for each subgroup). In the Cercon software, the finish line was marked, and the following parameters were introduced according to manufacture instruction, spacer thickness of 30μm covering all prepared surfaces till 0.5 mm away from the finish line. For groups {A2} and {B2}, using Cercon software, the copings were designed to have cervical zirconia collar extending 1mm height along the cervical margin. Each crown was given a number in the software that corresponds to its scanned stone working die. Finally, the zirconia copings were steam cleaned and were air dried. Then placed in ceramil furnace (*Henan Bofei Technology, China*) for 6-8 hours at 1350ºC (T_{max}=1350) for sintering.

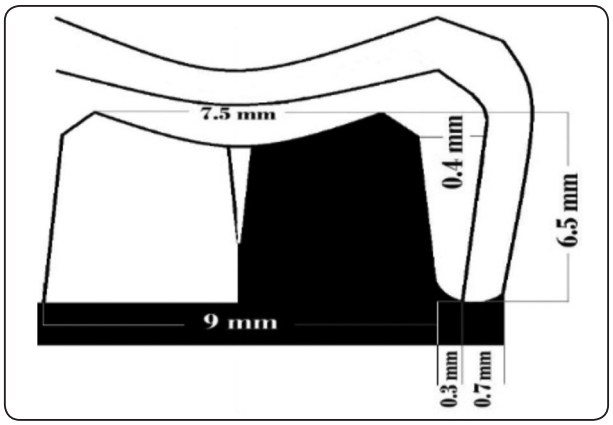

Fig. (1) A diagram representing posterior molar full coverage metal free crown preparation with its standardized dimensions

A Silicon Index from previously milled crown with full anatomy and contour was made to standardize the size and shape of porcelain veneer with a homogenous thickness ranging between 0.7 mm proximally and 1.5 mm occlusally. [30,32] Veneering of the copings was done using the direct building (layering) technique as follows: The copings were cleaned within 70% ethyl alcohol for 10 minutes in a digital ultrasonic cleaner. [2] Cercon Zirconia copings were veneered with a thin layer of Liner (*Cercon Ceram Kiss Paste*) using a brush to create an even layer to be fired at 960°C for 18 min. in Vacumat 40 furnace (*Vita Zahnfabrik, Bad Säckingen, Germany*).

Dentin powder was then mixed with the indicated liquid to form slurry. Using brush, the slurry was applied to the zirconia coping and vibrated for 30 sec., excess liquid was absorbed with a paper tissue then the copings were pre-heated in Vacumat 40 furnace to dry at 400°C for 6 minutes before the temperature was increased at 55°C/min. to 820°C under vacuum for 17 minutes. The space left by shrinkage was filled with a second layer of veneering material as the same manner for the first layer. Each coping was placed in the mold to ensure correct dimensions of the crown shape and then subjected to a second dentin firing cycle. The occlusal surface of the crown shapes was flattened and adjusted to the same height. Finally, the crowns were manually finished and polished before the glaze firing. [30]

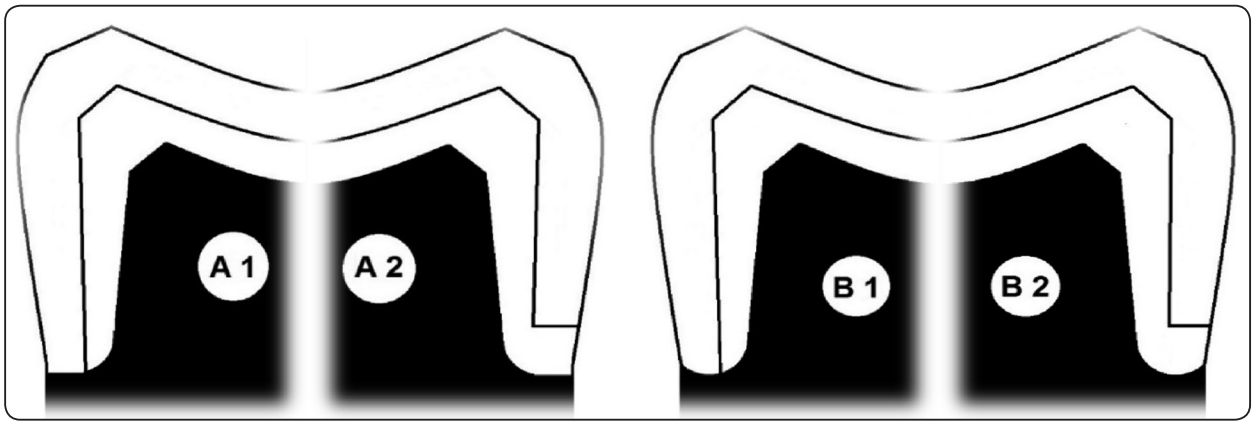

Fig. (2) A diagrams showing four margin designs used in this study

For Pre-Veneering Measurement of the Cercon Copings, a specially designed loading device was made to secure constant fixation and pressure to the zirconia crowns on the master dies and to provide constant perspective view during inspection of the margins when viewed from different points. The loading device consists of rotating flat circular base which allowed specimen-die assembly to move around its entire circumferential, this base was parallel to another one connected together with a metal bar, the upper and lower plates hold a portable U shaped metal plate with screw on the top for specimen fixation.

The measurements were done according to the marginal gap definition of Holmes et al.[31] (distance from the margin of the crown to the finish line of the preparation) using a traveling measuring microscope (*Henan Bofei Technology, China*). Readings for linear vertical gap distance (in micron) were measured at 18 predetermined points using the image analysis software (*Metrona Software, 4HJENA engineering, Jena, Germany*).[29] The mean of each 18 readings were calculated for each sample, then, the means were calculated for each group, then the mean for post-veneering Measurement of the final crowns was performed as described in the pre-veneering measurement of the copings in the same 18 points.

The data were collected and statistically analyzed using statistical-package of social science (SPSS) statistic software (*SPSS for windows, version 21.0, SPSS Inc. Chicago*).

RESULTS

This study was directed to analyze the collected data for the following variable factors: (1) veneering with porcelain (before and after veneering), (2) finish line design (shoulder and chamfer) and (3) presence or absence of cervical zirconia collar. Using paired t – test and ANOVA one-way test, descriptive statistics of the means (in microns) of 40 specimens and their corresponding standard deviation for each of the shoulder and chamfer finish line preparations before and after veneering with porcelain either with or without cervical zirconia collar are presented in the following table Table (1).

TABLE (1) Descriptive statistics of means (in microns)

Group	*Minimum*	*Maximum*	*Mean*	*Std. Dev.*
{A1}before	40.330	77.320	66.303	14.369
{A2} before	44.260	80.970	67.751	14.825
{B1} before	34.290	62.470	50.894	11.457
{B2} before	33.430	65.490	50.523	10.733
{A1} after	64.130	111.340	99.920	14.997
{A2} after	46.650	82.360	68.932	14.346
{B1} after	55.390	100.340	81.494	15.625
{B2} after	34.220	67.540	51.813	11.106

Concerning to veneering with porcelain (before and after veneering) Paired Samples Correlations for veneering with porcelain exhibited statistical significant difference in mean values of marginal gap distances in both group {A1} and {B1} coping designs (shoulder and chamfer without cervical zirconia collar) (*99.920±14.997 and 81.494±15.625*) respectively in comparison with the pre veneering state (*66.303±14.369 and 50.894±11.457*) respectively at the level of P value < 0.05. While veneering with porcelain did not exhibit statistical significant difference in mean values of marginal gap distances in both group {A2} and {B2} coping designs (shoulder and chamfer with cervical zirconia collar) (*68.932±14.346 and 51.813±15.625*) respectively in comparison with the pre veneering state (*67.751±14.825 and 50.523±10.733*) respectively at the level of P value < 0.05.

Concerning finish line design (shoulder and chamfer)Paired Samples Correlations based on the type of finish line design (either shoulder or

chamfer) exhibited statistical significant difference in mean values of marginal gap distances between all tested groups while in both group {A1 before}, {A2 before},{A1 after}, {A2 after} coping designs (shoulder finish line) the highest mean values of marginal gap distance were (*66.303±14.369, 67.751±14.825, 99.920±14.997 and 68.932±14.346*) respectively and in {B1 before}, {B2 before},{B1 after}, {B2 after} coping designs (chamfer finish line) the highest mean values of marginal gap distance were (*50.894±11.457, 50.523±10.733, 81.494 ±15.625 and 51.813±15.625*) respectively at the level of P value < 0.05.

Concerning presence or absence of cervical zirconia collar, Paired Samples Correlations based on presence or absence of cervical zirconia collar did not exhibited statistical significant difference in mean values of marginal gap distances between tested groups in pre–veneering state while in both group {A1 before} and {A2 before} the highest mean values of marginal gap distance were (*66.303±14.369 and 67.751±14.825*) respectively, however in {B1 before}and{B2 before} the highest mean values of marginal gap distance were (*50.894±11.457 and 50.523±10.733*) respectively at the level of P value < 0.05.

On other hand, there were statistical significant differences in mean values of marginal gap distances between tested groups in post veneering state, while in both group {A1 after}and {A2 after} the highest mean values of marginal gap distance were (*99.920±14.997 and 68.932±14.346*) respectively however in {B1 after}and {B2 after} the highest mean values of marginal gap distance were (*81.494±15.625 and 51.813±15.625*) respectively at the level of P value < 0.05.

DISCUSSION

Marginal fit play an important role for success of fixed restorations, where poor marginal fit may cause secondary caries, periodontitis and bone resorption[32]. The clinically accepted marginal gap distance of full coverage crown have been mentioned in numerous studies. Some of them have postulated that, marginal gap distance under 120 μm is clinically accepted. [36] But, others have reported that, marginal gap distance of 160 - 172 μm to be clinically acceptable. [34]

In this study, the vertical marginal gap distance was measured without cementation to eliminate the variability in the cementation procedure for each crown. [35] Also, viewing was used in this study using traveling measuring microscope instead of other measuring methods in the previous studies [36,37] for the following reasons: (a) it is a non-destructive, (b) a relatively simple method and (c) allow retrievability of measuring steps. [35]

Concerning to veneering with porcelain (before and after veneering); the results showed that statistically significant difference in mean values of marginal gap distances in both group {A1} and {B1} coping designs (shoulder and chamfer without cervical zirconia collar) in comparison with the pre veneering state, while veneering with porcelain did not exhibit statistical significant difference in mean values of marginal gap distances in both group {A2} and {B2} coping designs (shoulder and chamfer with cervical zirconia collar). This is may be attributed to that, the zirconia copings were not completely stable during the porcelain firing cycle (conventional layering technique needs at least three firing cycles in addition to glazing cycle)what is your reference for that while you already did 3 cycles . The shrinkage of veneering porcelain during sintering process may lead to changes in the gap, due to lifting of the ceramic from the margin. [38] Another reason is thermal incompatibility between framework and veneering porcelain. [39] where coping and porcelain veneer leads to stress formation when the restoration cools. [40] According to Isgro *et al*. even a zero thermal mismatch does not guarantee the compatibility between ceramic core and veneering porcelain, the visco-elastic behavior of the porcelain and rapid cooling procedure, may cause coping distortion. Another reason may be related to

the repeated firing cycles needed for each of these techniques, where conventional layering technique needs at least four firing cycle. [38] However, other studies argue that there are no changes in marginal discrepancies after veneering because the zirconia core still stable during veneering cycles. [41]

Concerning finish line design (shoulder and chamfer; In the current study, the marginal gap distance of zirconia crowns on chamfer finishing line was lower than that on shoulder finishing line and this may be attributed to the geometric design of chamfer finish line which provides difference in preparation depth which subsequently, influence on the accuracy of scanner detection. [42-44]This finding was in agreement with the results obtained by others. However, it disagrees with other studies [45] which preferred the shoulder finishing line as they suggested that all-ceramic crowns should be made with shoulder preparation to resist extensive loading whenever it may be expected, but, other previous studies [46-47] reported that the type of finish line design did not influence the marginal adaptation metal free restorations.

Concerning presence or absence of cervical zirconia collar; In current study, presence or absence of cervical zirconia collar did not exhibit statistical significant difference in mean values of marginal gap distances between tested groups in pre – veneering state On other hand, there were statistical significant differences in mean values of marginal gap distances between tested groups in post veneering state as a result of core rigidity which came from presence of cervical collar which lead to increase in the marginal thickness of the core that subsequently can resist the firing cycle of porcelain veneering [48] and this is in agreement with *Jalalian et al*.[49]

COCLUSIONS

Within the limitation of this study, the following conclusion were reported: (1) Marginal fit of the final crowns with chamfer finish lines were better than that with shoulder, however, (2) veneering with porcelain significantly raised marginal gap distance of crowns with collarless shoulder and chamfer preparations, while (3) in that designs with cervical collar, veneering was not significantly affected on the marginal gap distance for both finish line designs.

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