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Evaluation of marginal fit of vertical versus horizontal finishing line designs of monolithic zirconia crowns (invitro study)

Mostafa Mohamed[1], Khalid Hassan [2] , Tamer A hamza [3]
1 Assistant lecturer, Department of Crown and Bridge, Faculty of Dentistry (Assuit branch), Al-Azhar University
2Dean and Professor Department of Oral Medicine, Faculty of Dentistry (Assuit branch), Al-Azhar University
3Dean and professor of prosthodontic Department Badr University in Cairo (BUC)

AbstractThe aim of this invitro study was to evaluate the influence of two kinds of finishing line (FL) preparation designs (biologically oriented preparation technique (BOPT) and chamfer) on marginal fit of monolithic zirconia (ZrO2) crowns in anterior teeth.Material and Methods: as this study is a supplementation for a clinical part accomplished at the same time, so A total of 16 metal dies of upper two central were milled from STL file of in vivo case to replicate the creation of an all-ceramic full-coverage crown for central incisor teeth with two types of finish lines and thenThe monolithic zirconia restorations were fabricated by using a CAD/CAM system equipped with a scanner to digitalize the prepared metal dies. The marginal fit was evaluated bystereomicroscope..

Conclusions: The marginal fit of both BOPT and chamfer designs was within the clinical acceptance limit.

Keywords:*Finishing line , Marginal fit, monolithic zirconia crowns, Horizontal preparation, vertical preparation.*

I. INTRODUCTION

Zirconia is an example of a ceramic material that must meet mechanical requirements and offer lifespan and good marginal adaptability on par with conventional metal-ceramic prosthesis [1]. The biocompatibility and physical attributes of ZrO_2 restorations, in addition to giving them a more natural appearance, are highly regarded by clinicians for their improved chemical stability, high fracture toughness, and flexural strength [2]. Additionally, manufacturing milling of ZrO_2, even at a thin thickness, did not result in any structural modification both before and after the chewing simulation [3].

Typically, the tooth on which the prosthetic restoration rests is marked with a finish line by clinicians preparing dental abutments for fixed partial dentures (FPD) [4, 5]. These finish lines can be divided into two primary categories: vertical lines, which include feather or knife-edge margins, or horizontal lines, which include chamfer, deep chamfer, and shoulder with bevel. Some writers advise using the BOPT, an alternative to the dental preparation approach without a completion line [6, 7]. The distinction between horizontal and vertical preparation is that in the former, the margin is placed on the tooth by the dentist, leaving a clearly defined line that is subsequently repeated in the impression and working model [8, 9]. Prosthodontists presumably prefer horizontal preparation for this reason [7].

However, there are several benefits to this preparation method without a goal in sight. Both teeth that have not been prepped and teeth that have been, with the latter removing the pre-existing finish line, can have their cementoenamel junction (CEJ) positions corrected by clinicians [10]. The prosthesis is positioned so that it leaves the gingival margin in the proper position, creating a new prosthetic CEJ at the same time (obtaining the optimal aesthetic outcome in cases of compromised esthetics) [4, 7]. The technicians place the margin for vertical preparation based on the gingival tissue data. The fabrication of the interim prosthesis, which will be replicated when the final prosthesis is inserted, is crucial to the success of BOPT preparation design because it determines the new emergence that will support the gingival margin and direct healing, reinsertion, and thickening of the gingival tissue [11, 12].

A key indicator of ceramic restorations' clinical success is the marginal fit [13, 14]. There is still no agreement on what constitutes a clinically acceptable marginal fit. It was stated that the acceptable marginal fit values for cemented restorations have been reported to range from 100 to 200 µm [13]. However, some research has found that a marginal fit of 100-150 µm is more appropriate [15]. Other studies suggest that a marginal fit of 120 µm is clinically acceptable [7, 10]

II. MATERIALS AND METHODS

The samples of this study was conducted on 16 anterior monolithic zirconia crowns of two different finishing line designs (8 crowns with vertical “BOPT” FL and 8 crowns with cervical “chamfer” FL) placed on metal dies of maxillary central incisor teeth to evaluate the marginal fit of both FL designs.

Metal dies preparation:

As this study was designed as a part of a split-mouth two-parallel arm study (Laboratory “in vitro” study and intervention “clinical” study).

Impressions of the entire arch were taken by using a PVS impression material (Elite HD+, ZermachSpA- Via Bovazecchino, BadiaPolesine (RO), Italy) and a perforated plastic tray, and the prepared teeth from each group's imprint were captured using the putty-wash procedure [5]. The impression of each preparation was scanned with a lab scanner (Ceramill map400, AMANNGIRRBACH, Herrschaftswiesen1, Koblach, Austria), and an STL file of each preparation was created. The CAD/CAM milling wax (D Wax- w16, DMAX Co Ltd, Dalseong-gun, Daegu, Korea) was patterned for each preparation group (8 per group) and was created from each STL file. Each preparation's wax design was then sprued, invested, burned off, and cast using hard gypsum (Calibra-Express, Protechno, C/ Rabós de Empordà, Girona, Spain) for non-precious dental casting alloy (System NH, Adentatec, Konrad, Köln, Germany). After casting, each metal die was smoothed with a rubber wheel and polished with pumice in a lathe brushfollowed by a rouge to gain a smooth polished surface, so that no interference with the seating of all crowns could occur later [16]. (Fig. 1)

For the measurement of the vertical marginal gap, five equidistant marks (mesial, distal, buccal, and palatal) were carved on each die to orient the stereomicroscope for the marginal gap measurement. An occlusal bevel was prepared at the occlusal-axial line angle of the buccal surface of the metal die for exact repositioning of the crowns during the cementation. For ease of identification, serial numbers were carved on the bottom of the metal dies [13].

Fabrication of monolithic Zirconia crowns:

The monolithic zirconia restorations were fabricated by using a CAD/CAM system equipped with a scanner to digitalize the prepared metal dies [5]. After scanning the metal dies with a lab scanner [13]. CEREC 3D Software (AMANNGIRRBACH, Herrschaftswiesen1, Koblach, Austria) was used for designing standardized monolithic ceramic crowns. For the fabrication of super-high translucent zirconia crowns, the STL file of the crown design was transferred to the Cerec MCX5 milling machine (Ceramill motion2, AMANNGIRRBACH, Herrschaftswiesen1, Koblach, Austria) to be milled in an oversize dimension with the green stage zirconia blanks (AMANNGIRRBACH, Herrschaftswiesen1, Koblach, Austria) in order to compensate for the dimensional shrinkage of 25–30% [13]. The milled super-high translucent zirconia crowns were then sintered in a furnace (CeramillTherm, AMANNGIRRBACH, Herrschaftswiesen1, Koblach, Austria), according to the manufacturer’s recommended firing parameters, at a temperature of 1450°C for a 120-minute holding period, which concluded with a sintering process that took a total of 7.5 hours for each zirconia crown [13].

Measurement of the marginal gap:

After fabrication, all the monolithic zirconia crown restorations were tried on their corresponding metal dies and checked for complete seating. The crowns were then cemented with conventional glass ionomer cement (Medicem application capsules, ProMedica Dental Materials GmbH, Domgkstrasse, Germany), and the crowns were subjected to a static load of 49N with a screw-loaded holding device for five minutes the excess cement was then removed with a hand scaler [13, 17]. A specially created metal jig was utilized to hold the specimens during the measurements of the cervical vertical marginal discrepancies. Stereomicrographs of each specimen were taken using a digital camera attached to a stereomicroscope (Nikon SMZ5T Stereomicroscope, Nikon, Japan) at a magnification of 70X [13]. For each crown, the marginal adaptability measurements were taken every 20 points (5 readings per buccal, lingual, mesial, and distal surface) [13, 18]. The computer system was then used to transfer the images for analysis. The vertical gaps between the cervical border of the crown and the outer end of the finish line were automatically determined using the image analysis software (Omnimet Buehler USA) at five distinct locations in each stereomicrograph [13]. (Fig. 2) Next, a calculation and tabulation of the mean vertical gap (in microns) for each specimen were done for statistical purposes.

Figure 1.A photograph shows. A, TheBOPT design. B, The chamfer finish line design on the metal die.

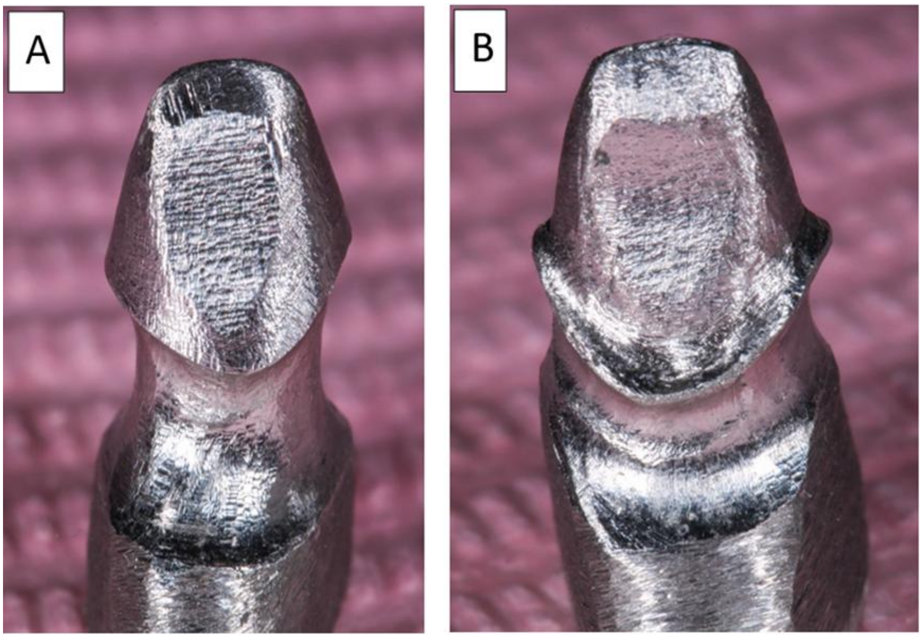
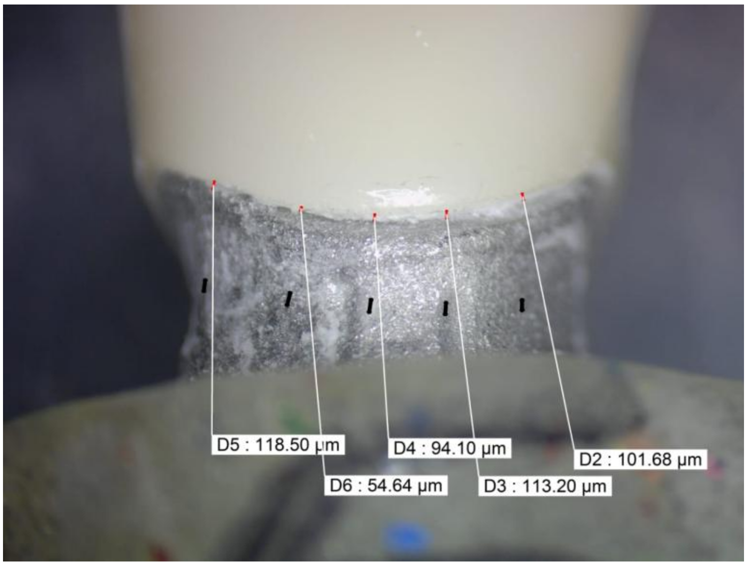


Figure 2.A stereomicrograph showing the predetermined 5 points on the buccal surface.



III. RESULTS

The normality assumption was checked based on the Shapiro-Wilk Test, it is assumed that the data is normally distributed. The unpaired t-test results regarding the overall marginal fit revealed that the difference between the sample average of the BOPT group and the Chamfer FL group is big enough to be statistically significant. The results revealed that the Ch group recorded a higher significant mean overall marginal fit value, while the Bo group recorded a lower significant overall marginal fit value. (Table 1)

Table 1. Comparison of the overall marginal fit results:

Variable	Mean (µm)	SD	t-value	p-value
Bo group**	49.86	19.19	5.73	0.00005*
Ch group***	96.07	12.27		

*significant ($p<0.05$).

***Bo: biologically oriented preparatipon technique

***Ch.: chamfer finishing line

IV. DISCUSSION

It would be crucial that these preparation methods would not jeopardize adequate marginal fit and emergency profile because marginal integrity significantly c Therefore, this study was aimed to evaluate the effect of the chamfer finish line and BOPT designs on the marginal fit of zirconia crowns contributes to the durability and long-term success of restorations.[13]

The idea of minimally invasive preparation is crucial for effective restorations. The ultimate aim of reconstructive dentistry is to preserve biological features while achieving outstanding aesthetic results.[19] Successful restorations require the concept of minimally invasive dental restorations. As a result, minimum-thickness ceramic restorations have become more and more recommended.[13] Therefore, in this study, BOPT was selected as the tested group due to its most acute marginal restoration.[19] It is vital to note that, when considering crucial elements like finish line design, cement type, and material type, a large degree of disparity in marginal fit is seen for these various ceramic systems [13]. Therefore, in this current study, we have chosen a single material (monolithic zirconia) and GIC for both preparation designs in both parts of the study in order to avoid biased results of other factors as the main goal of this research was to examine the effect of the two tested finishing lines on marginal fit. Moreover, it is conceivable to reuse specimens in studies of temporary types of cement, but it is obviously impossible to do so in research of definitive cement or bonding methods on teeth [20]. The researcher can utilize several bonding processes when using natural teeth, which significantly affects the behavior of the materials under the inquiry.[21] Another problem is that the materials used to make hand-crafted stump specimens, like polymethylmethacrylate (PMMA), epoxy resins, and noble metals, typically behave differently from actual teeth. Moreover, some of these materials also prevent the use of modern bonding procedures.[22]

Therefore, in order to allow the standardization of the preparation of real teeth in this present study during vitro testing the CAD/CAM technology was utilized to duplicate the actual tooth preparation However, the metal alloys used in this study are an expensive material but the use of CAD/CAM technology in wax model printing allows exactly duplicated models in this current investigation. This is because it was stated that it would be considerably simpler to compare the data gathered between the studies and extend the findings to other study circumstances if dental specimens were used that were digitally standardized.[19, 21] Moreover, it was stated that the failure to standardize stump manufacturing techniques and the dearth of documentation on the production of reproducible specimens make it impossible to compare the opposite outcomes of laboratory tests.[21] The manufacturing and replication processes, however, are technique-sensitive and prone to a variety of faults.[23]

In this present investigation, the monolithic zirconia was selected in order to avoid the bias of marginal adaptability distortion due to firing shrinkage because it was found that during the veneering stage in the veneered zirconia, which is carried out at relatively higher temperatures, the framework is prone to distortion and shrinkage. As a result, marginal adaptability may be negatively impacted.[24] Moreover, high translucent zirconia crowns were chosen for the investigation because of their excellent toughness and strength, and ease of milling. Pre-sintered zirconia is less hard than other ceramic materials, and it can be milled more easily and with less pressure.[13]

The marginal adaptability was selected in this current study as a test property for long-term restoration success that is significantly influenced by the degree of adaptability between the tooth and the repair.[25] In order to reduce the viscosity effect of the luting agents, cementation was carried out in a controlled way under constant load.[26] Moreover, direct viewing with external measurements, as was done in this work using a stereomicroscope because has the advantage of being non-invasive and hence suitable for clinical practice.[27]

For each crown in this present study, the marginal adaptability measurements were taken every 20 points per crown. This is because a measurement of at least 20 to 25 measurements per crown was recommended by Groten and others.[28] In past research,[26, 28] either larger sample sizes ranging from 5-10 specimens or an increased number of measurements from different sites were used to establish the reproducibility of the marginal opening measurements. In the present investigation, up to 160 measurement points per group were obtained from 8 specimens for each style of the finish line. The number of measurements and specimen size were within the advised ranges. The outcomes of the power analysis also supported the accuracy of the sample size and measurements. The results revealed a significant difference between the various forms of preparation used with regard to the marginal fit and gingival thickening response, so, the null hypothesis was rejected.

The results of marginal adaptation in this present study revealed that the chamfer finishing line recorded a significantly higher total marginal gap while the BOPT finishing line recorded a significantly lower total marginal gap. This was explained by the observation that, the distance between the restoration margin and the tooth is shorter the more acutely the restoration edge ends. These results are in accordance with the results of a study by Cömlekoglu et al. (2009),[26] who reported that the finish line with a feather edge had the least amount of marginal variation when compared with the other horizontal finishing lines.

It has been demonstrated that shrinkage stress spreads further across the perimeter of the margin as the coping margin starts to bend under the pressure of contracting porcelain. The fit of the coping changes as a result of non-uniform distortion during porcelain firing and the asymmetrical form of the coping margin because porcelain shrinks towards its greatest mass [26]. It is conceivable that finish lines could cause thin margins to experience greater shrinkage, which would lead to poorer marginal adaptation.[29] The measurements' findings showed that the finish line design with a featheredge had the least noticeable variation, as previously described by Schillinburg (2019),[30] with the following formula: d= D sin m (d: marginal opening; D: the distance by which a crown fails to seat; and m: the acute angle of the margin), the more the restoration margin ends with an acute angle, the shorter the distance between the restoration margin and the tooth.

Furthermore. In many ways, including creep behavior, the rheological characteristics of zirconia material are different from those of other ceramic materials.[31] This could be the reason why the current study's chamfer finish line-designed crowns fit poorly. Moreover, the results of marginal adaptation in this present study revealed that the chamfer finishing line recorded a total marginal gap of (96.07±12.27) while the BOPT finishing line recorded a total marginal gap of (49.86±19.19), while both finishing lines exhibited marginal gaps within the clinically acceptable levels.

However, Vigolo et al,^[32] stated that the marginal fit of single-unit zirconia crowns made with a vertical finish line was found to be comparable to the marginal fit of single-unit zirconia crowns made with the more traditional horizontal finish line, opposing to the findings of the current study. However, in accordance with the results of this study, numerous in vitro and in vivo studies have shown that when compared to other preparation designs, the featheredge preparation exhibits the least marginal discrepancy.[26, 33, 34]

conclusions

The findings of this study showed that for monolithic zirconia crowns with different finishing line designs; The preparation design may have an impact on how zirconia ceramic restorations adapt. The chamfer finish line significantly decreases the marginal fits compared to the BOPT finish line. The marginal fit values of monolithic ceramic crowns were all within the range of clinically acceptable values despite the statistical discrepancies between the two margin designs in the current investigation.

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