Original Article

Marginal adaptation of zirconia CAD-CAM copings with two cervical finish lines

Maryam Moslemioon[1], Faeze Zanjani Jam[2], Rasoul Moharami[3], Atefeh Yousefi Jordehi[4]

Abstract

Introduction: Marginal adaptation is important for the long-term success of restorations. The finish line design can influence the marginal integrity. This study aimed to evaluate the effect of radial shoulder and deep chamfer finish line designs on the marginal adaptation of zirconia copings fabricated by the CAD-CAM system.

Methods: In this experimental study, a standard chrome-cobalt die (height: 7mm, diameter: 5mm) was designed by software. The data were sent to a 3D printer device, and the resin pattern of the standard die was fabricated. After casting the resin pattern, a standard chrome-cobalt die was obtained with a 1-mm radial shoulder finish line and a 0.8-mm deep chamfer finish line. The walls were 12° converge (6° each) towards the occlusal surface. The standard die was replicated 9 times with a polyvinyl siloxane elastomeric material and poured with type IV dental stone. Zirconia copings were fabricated, and the vertical gap at 8 points was measured by a stereo microscope. Data were analyzed by the t-test, and statistical significance was set at α=0.05.

Results: The vertical gap values were 102.91 µm for deep chamfer and 82.42 µm for radial shoulder finish lines. There was no significant difference between the two preparation designs in terms of the mean vertical gap (P=0.098).

Conclusion: The results of this study showed clinically acceptable marginal adaptation values for both deep chamfer and radial shoulder preparation designs without a statistically significant difference. *(J Dent Mater Tech 2023;12(1): 16-21)*

Keywords: *CAD-CAM, Marginal adaptation, Zirconia*

Introduction

The longevity of full coverage restorations depends on their marginal fit, as a marginal discrepancy between the restoration and abutment can cause several problems (1, 2). Caries can be caused by cement breakdown, plaque retention, and microleakage. Furthermore, periodontal tissue inflammation, bone loss, and treatment failure may occur in the case of marginal discrepancies (3). A five-year study of 1,000 restorations by Mclean and Fraunhofer (4) concluded that a marginal discrepancy within the range of 100 µm is clinically acceptable. Computer-aided design/computer-aided manufacturing (CAD/CAM) process decreases the possibility of human error and the inaccuracy of different materials. For this reason, the generally acceptable marginal gap discrepancies are 50 to 100 µm for CAD/CAM restorations (5).

Nowadays, all-ceramic crowns are popular for their reliable aesthetics and biocompatibility. Zirconia is a commonly used ceramic material due to excellent properties, such as low plaque accumulation, high strength, and biocompatibility (6). CAD/CAM technology has been developed to fabricate zirconia restorations (7). Products of this system are biomimetic, and exhibit high mechanical properties like flexural strength and fracture toughness compared to the conventional fabrication procedures (8-10). The marginal adaptation of all-ceramic restorations depends on factors, such as the fabrication process, preparation pattern, and type of utilized ceramic (11, 12).

Various methods are available to evaluate marginal discrepancies, including stereo microscopy, scanning electron microscopy, cross-sectioning techniques,

[1]Department of Prosthodontics, School of Dentistry, Zanjan University of Medical Sciences, Zanjan, Iran.
[2]Undergraduate Student, Zanjan University of Medical Sciences, Zanjan, Iran
[3]Mechanical Department, University of Zanjan, Zanjan, Iran.
[4]Department of Operative Dentistry, School of Dentistry, Zanjan University of Medical Sciences, Zanjan, Iran.

Corresponding Author: Atefeh Yousefi Jordehi
Department of Operative Dentistry, School of Dentistry, Zanjan University of Medical Sciences, Zanjan, Iran
Email: dr.yousefi.j@gmail.com

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radiographic techniques, impression replica techniques, profilometry, digital quantitative evaluations, and microcomputed X-ray tomography (13). Stereo microscopy is particularly advantageous due to the accuracy and precision in the repeated measurements (14).

Nowadays, deep chamfer and radial shoulder finish lines are generally used for zirconia restorations. Previous studies have reported conflicting results about the impact of finish line type on the marginal fit of ceramic restorations (15). Jalalian et al. (16) found that the vertical discrepancy of a sloped shoulder finish line is notably lower than that of a deep chamfer finish line. In contrast, Zakavi et al. (17) showed that the marginal adaptation of feldspathic crowns is significantly higher in the chamfer finish line, compared to the shoulder design. Another study by Dino Re et al. (18) found no significant difference between shoulder and chamfer designs in terms of the marginal adaptation of LAVA CAD-CAM crown copings.

Because of the contradictory findings of previous studies, the current study aimed to evaluate the marginal adaptation of zirconia CAD-CAM copings prepared with two cervical finish lines. The null hypothesis was that the marginal adaptation of zirconia copings is not different between the two finish line designs.

Materials and Methods

This study was registered with the ethics code of IR.ZUMS.REC.1398.355. In this experimental study, a standard chrome-cobalt die (height: 7mm, diameter: 5mm) was designed by software (SolidWorks 2019, JB-Team Software Developer, Tehran, Iran). The data were sent to a 3D-printer device (Bonyan Mechatronic 3D Printer, Pixgold, Aniwaa, Tabriz, Iran), and the resin pattern of the standard die (3D Print Resin, Free Print Model, Detax, Germany) was fabricated. After casting the resin pattern, a standard chrome-cobalt die was obtained with a 1-mm radial shoulder finish line and a 0.8-mm deep chamfer finish line (Fig 1). The walls were 12° converge (6° each) towards the occlusal surface. An anti-rotational feature was prepared using a 45° ledge at the occluso-axial line angle.

The die was visually checked for any possible irregularity by binocular loupes (Kindle medical devices Co. Ltd, Shenzhen, China). The master die was placed in a mold, and its parallelism was assessed using a surveyor (Novo Export Limited, Shenzhen, China). Next, a special tray was prepared using acrylic resin (Cold-Cure Acrylic for Special Tray, Acropars, Marlic Medical Industries Co, Iran) to fill the mold. In this way, the acrylic surface was 2 mm below the margin of the standard die.

The standard die was replicated 9 times with putty and wash technique using a polyvinyl siloxane elastomeric material (Betasil, Addition Curing Polyvinylsiloxane, Type 0, Putty Consistency, Germany & Betasil, Addition Curing Polyvinylsiloxane, Type 3, Light-bodied Consistency, Germany). The sample size was determined

Figure 1: The chrome-cobalt standard die with two cervical finish lines

as n=9 for this study based on a previous research (19). A wing that resulted from meeting two finish lines led to having only one path of insertion. Impressions were poured with type IV dental stone (Improved Type 4 Dental Stone, Well Mix G30, Aria Dent, Iran).

Scanning of working dies was done using a scanner (Maestro MDS 500 professional Lab Scanner, Italy). After transferring the scans to a computer, zirconia copings were designed by software (Exocad Dental CAD-LUX Dental Supply, Italy). The thickness of the copings was determined to be 0.5 mm, and the die spacer (Tru-Fit, George Taub products, NJ, USA) was applied at an approximate thickness of 30 µm, 1mm shorter than the margin. Semi-sintered zirconia blocks (Aidite Multilayer Dental Zirconia Ceramic Blocks, China) were transferred to the milling machine (Dental Milling Machine for chairside & Lab, Benco Dental, USA), and the copings were sintered (Ceramill therm, AmannGirrbach, Germany) at 1500° C. Veneering of copings with porcelain was not done.

The manufactured copings were mounted on the standard die one by one (Fig 2) using a fixation device for the application of constant load parallel to the long axis of the copings during the measuring process. The vertical marginal discrepancy was analyzed between the copings and the master die margin under a stereo microscope (ED Plan 2 X WD 32.5, Nikon, Japan) at a precision of 1 µm at 50 X magnification.

In total, 8 measurements for each coping were made based on marked reference points: 4 points in the deep chamfer half, and 4 points in the radial shoulder half with equal distances from each other. After that, 4 images were captured for each coping. An image-processing software (MIP 4.2 Full, Nahamin Pardazane Asia CO, Mashhad, Iran) was used to measure the vertical gap between copings and die margins (Fig 3).

All measurements were performed by one operator and repeated 3 times to achieve precise and accurate readings. The data were tabulated, and mean ± SD values were calculated. The distribution of data was evaluated for normality using the Kolmogorov-Smirnov test ($P > 0.05$), and the t-test was used to compare the two groups. The significant level was determined to be 0.05, and the data were analyzed using SPSS software (version 24 , SPSS Inc., Chicago, IL, USA).

Results

The mean vertical gap value was 102.91 µm for deep chamfer, and 82.42 µm for radial shoulder finish lines. Table 1 presents the mean ± SD values of the vertical gap in the study groups.

The student t-test revealed no significant difference between the two preparation designs in terms of the mean vertical gap (P=0.098).

Figure 2: Zirconia copings

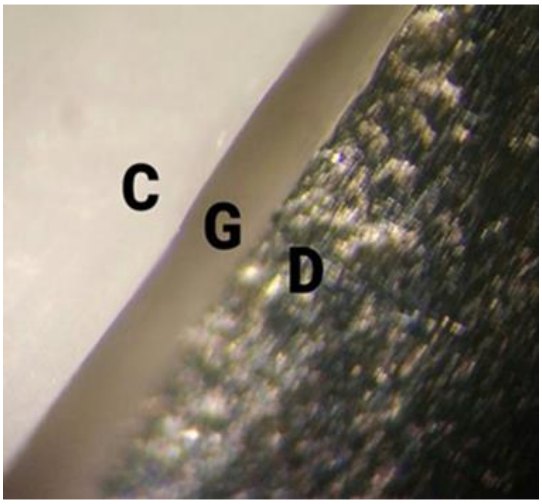

Figure 3: Microscopic view of the vertical gap (C: Coping, G: Gap, D: Die)

Table 1: Descriptive statistics of marginal gap for deep chamfer and radial shoulder preparation designs

Group	Mean	SD	Minimum	Maximum	P-value
Deep chamfer	102.91	61.57	35.51	265.41	0.098
Radial shoulder	82.42	43.77	31.38	198.80	

SD: Standard deviation

Discussion

This study was conducted to assess the effect of deep chamfer and radial shoulder preparation designs on the marginal adaptation of zirconia copings. The results showed that the vertical gap was within the clinically acceptable rang for the two groups, and there was no significant difference between the evaluated groups in this regard. Therefore, both margins can be successfully used in terms of marginal adaptation, and the null hypothesis was approved. The mean vertical gap values were 102.91µm and 82.42µm for deep chamfer and radial shoulder finish lines, respectively. It has been suggested that differences in preparation designs may have an impact on the accuracy of the scanner detection (20).

Akbar et.al. (21) reported no significant fit difference between the chamfer and shoulder finish lines and concluded that the marginal integrity of CAD/CAM ceramic crowns was acceptable for both finish lines. This result is consistent with the findings of the present study. Habib et al. (22) evaluated the marginal adaptation of zirconia copings with chamfer and shoulder finish lines and found no statistically significant fit difference between the two types of margin designs. They used natural teeth which can cause adverse effects on the standardization of preparations. In addition, they cemented copings on teeth, and after sectioning, the measurements of vertical discrepancy were done (22). In the present study, the cementation process was eliminated because it can affect marginal adaptation. Furthermore, the produced heat in the sectioning procedure can cause distortion in margins and compromise measurement accuracy.

Some studies evaluated the effect of different finish lines on the marginal adaptation of CAD-CAM ceramic crowns, and showed significantly better marginal adaptation in the chamfer design. Other studies concluded that the best marginal fit of crowns belonged to the rounded shoulder finish line (13,17). The type of selected dental ceramic can lead to different results. The stiffness of zirconia is higher than lithium disilicate, and the risk of chipping between the two types of ceramics is different (23). Moreover, some authors used crowns to evaluate marginal adaptation; but in this study, copings were used, and the porcelain firing phase was no longer necessary. Alrashdan et al (24) found that evaluation of the zirconia coping was more reliable than veneered zirconia to determine the system fabrication precision with respect to the marginal fit (24). In another study, Souza et.al. (25). showed better marginal adaptation in the rounded shoulder finish line, compared to tilted and large chamfer in CAD-CAM ceramic copings. Differences in results between studies can be due to differences in materials used, ceramic fabricating methods, type of gap measuring system, porcelain firing, and cementation process.

The utilization of the standard die with both finish lines was the strength of this study due to creating ideal and identical testing conditions in both groups. In addition, the number of influential factors on the marginal adaptation decreased as a result of the elimination of the porcelain firing phase and cementation process. Furthermore, the application of a fixation device minimized improper coping seating on the die during vertical discrepancy measurements.

Since this study assessed only one type of discrepancy, further studies are required to evaluate both internal and marginal gaps. It should be mentioned that this *in vitro* study suffers from the general limitations of the laboratory conditions. Therefore, the results should be further verified in the clinical setting.

Conclusion

The results of this study showed clinically acceptable marginal adaptation values for both deep chamfer and radial shoulder preparation designs without a statistically significant difference. Therefore, the selection of the preparation design should be performed based on other factors, such as resistance to fatigue or fracture.

Conflict of Interest

The authors of this manuscript certify that they have no conflict of interest.

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