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Marginal Accuracy of Monolithic Zirconia Crowns with Vertical and Horizontal Margin Configurations after Thermomechanical Fatigue

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ABSTRACT

Purpose: The aim of this study was to evaluate the effect of two types of finish line designs on the marginal accuracy of monolithic zirconia crowns after thermo-mechanical fatigue. **Materials and Methods:** two human first molars were prepared and duplicated using epoxy resin to produce twenty dies. Accordingly, a total of 20 monolithic zirconia crowns (N=20) were designed and constructed using CAD/ CAM machine. The crowns were divided into two groups according to the finish line design, feather edge (FE) group (n=10) and deep chamfer (DC) group (n=10). All crowns were adhesively bonded to their corresponding epoxy resin dies by using dual cure self-adhesive resin cement and subjected to thermo-mechanical fatigue simulating 3 months of clinical situations then vertical marginal gap was measured using digital microscope. **Results:** Statistical analysis showed that deep chamfer margin design recorded statistically significant higher marginal gap mean value (39.6383 ± 5.00193 μm) than feather edge design (32.2616 ± 2.60053μm). **Conclusion:** marginal accuracy of monolithic zirconia constructed with feather edge margins is better than that with deep chamfer margin designs.

KEYWORDS

Zirconia crowns, marginal accuracy, finish line, monolithic.

INTRODUCTION

Zirconia restorations provide the mechanical performance (high flexural strength and fracture resistance), excellent marginal accuracy, and ageing values comparable to ceramo-metallic crowns [(1)]. Zirconia restorations have superior mechanical, chemical and biological properties that surpass any other type of ceramic restorations, zirconia

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ceramic has been studied extensively and has many applications in dentistry [2, 3]. The restoration can be milled from monoblock with no porcelain veneer [3] or as a framework to be veneered with veneering ceramic[4]. The edge chipping of the veneering ceramic is the most cause of failure of zirconia veneer system [3].

With advancement in CAD/CAM technology, which facilitates the fabrication of monolithic restorations from monoblock and with the development of highly translucent zirconia blocks and blanks; it is now possible to fabricate monolithic Y-TZP anterior and posterior crowns and fixed dental prosthesis (FDPs) without veneering porcelain chipping [3].

Tooth preparations without a defined finish line are generally named vertical preparations[5]. Historically, vertical preparations have been defined as knife edge, feather edge, or shoulder-less preparations, and they were frequently associated with a less accurate margin, opposite to horizontal designs (shoulder and chamfers) which had been frequently used [5]. In theory, preserving a maximum amount of sound tooth structure during tooth preparation for fixed abutments is achievable in vertical preparations as these designs provide acute marginal finish line and so provide preservation of healthy dental tissues. Vertical finish lines had been introduced to the dental field in conjunction with the advent of new materials and techniques [6].

Marginal and internal adaptations are important criteria for successful restorations. The perpendicular distance from internal surface of the restoration to the axial wall of the preparation is called as internal adaptation [7]. Meanwhile, marginal adaptation is defined as the degree of approximation or fit of dental prosthesis to the tooth surface. A close marginal adaptation and seal at the interface ensures a successful dental restoration [8]. On the other hand, defective margin or internal adaptation can result in adhesive resin dissolution, micro-leakage, plaque accumulation, recurrent decayed, periodontal problems, marginal discoloration, and fracture due to higher stress concentration because of poor adaptations [7].

Therefore, the purpose of the present study was set to evaluate the effect of two types of finish line designs (1mm deep chamfer, and 0.25mm feather edge) on the marginal accuracy of monolithic zirconia crowns after thermo-mechanical fatigue.

MATERIAL AND METHODS

Two anonymous (of unknown donor) extracted sound maxillary first permanent molars were selected from clinic of oral and maxillofacial surgery department, faculty of dental medicine for girls, Al Azhar University, Egypt, and used in this study. Research ethics committee approval of faculty of dental medicine for girls was obtained (Ethics code: REC-CR-19-02). Each molar was embedded in the center of plastic cylinder (2cm height and 2cm diameter) filled with epoxy resin. The molars were prepared by CNC (centroid milling machine) for achieving standardization [9]. Each molar was prepared to have 5mm occluso-cervical height, 6 degree axial taper for each wall (a total convergence of 12 degree). One molar was prepared with deep chamfer finish line (1mm) [10] and the other with feather edge finish line (0.25mm) [11].

Each molar was duplicated by using silicon molds fabricated from duplicating addition silicon material to form 10 epoxy resin dies (10 dies for each finish line design). The twenty constructed dies were optically scanned for fabrication of 20 monolithic single crowns (n=20) using CAD/CAM machine. Each epoxy die was sprayed with IP scan- spray (Germany), and then scanned by the S600 ARTI scanner (Zirkonzahn USA, Inc). The crowns were designed by using Zirkonzahn Archive software. The milling unit M1(Zirkonzahn, Italy) was used to mill Prettau zirconia blank (Zirkonzahn, Italy) to produce twenty (N=20) CAD/CAM milled monolithic zirconia crowns, 10 crowns with 1.0±0.2mm deep chamfer finish line, and 10 crowns with 0.25±0.05mm feather edge finish line.

Cementation procedure was followed according to the manufacturer recommendations with

sandblasting of the fitting surface of all samples using aluminum oxide, grain size 110 μm; at 3.5 bar pressure then all samples were cleaned with ultrasonic cleaner. All crowns were cemented to their corresponding dies using dual- curing self-adhesive resin cement (Theracem, BISCO. Inc. Schaumburg, IL60193 U.S.A) under constant 2Kg load in a specially constructed loading device till complete setting of resin cement [10].

Thermo-mechanical fatigue procedure:

Mechanical fatigue test was performed using the Robota chewing simulator integrated with thermo-cyclic protocol operated on servo-motor (Model ACH-9075DC-T, AD-Tech Technology CO, LTD., Germany). Each sample was exposed to 37500 cyclic loading in chewing simulator device using 5Kg weight according to the criteria shown in Table (1), simultaneously with thermal cycles between 5˚C and 55˚C simulating 3 months of clinical condition[12].

Table (1) *Chewing simulation test parameters*

Vertical movement: 3 mm	Horizontal movement: 1 mm
Rising speed: 90 mm/s	Forward speed: 90 mm/s
Descending speed: 40 mm/s	Backward speed: 40 mm/s
Cycle frequency 1.6 Hz	Weight per sample: 5 kg
Torque; 2.4	

Marginal accuracy evaluation after cementation and thermo-mechanical aging:

Marginal accuracy of constructed monolithic crowns was evaluated in terms of measured vertical marginal gap at specific points. Each specimen was photographed using USB digital microscope (U500X Digital Microscope, Guangdong, China)with a built-in camera connected with an IBM compatible personal computer using fixed magnification X=30. A digital image analysis system was used to measure and evaluate the gap width. Shots of the margins were taken for each sample, then morphometric measurements were done for each shot at 3 equidistant landmarks along the circumference of each surface (buccal, mesial, lingual, and distal). Measurement at each point was repeated three times. Then the data obtained were collected, tabulated, and statistically analyzed. At the end of the study teeth were disposed in medical waste container.

RESULTS

Independent t test was used for intergroup comparison and it was found that higher marginal gap mean value was recorded in Deep chamfer group (DC Group) 39.64±5.81, in comparison to Feather edge group (FE Group) 32.26±3.05, with a mean difference between groups (7.38). This difference was statistically significant (p=0.00), table (2)**.**

Digital microscopic photographs. Fig.1 (A and B), show smooth and continuous margin in both tested groups.

Table (2): *Descriptive statistics and comparison of gap values between groups (independent t test)*

Groups	Mean	Std. Dev	Std. Error Mean	Difference		CI. Lower	CI. Upper	T	P Value
				Mean	Std. Error				
FE	32.26	3.05	.97	7.38	2.08	11.84	2.91	3.55	.00*
DC	39.64	5.81	1.84						

*C.I. = 95% Confidence Interval of the Difference, Significance level p≤0.05, *significant.*

Figure 1 (A)**:** Digital microscopic image for marginal gap of feather edge design

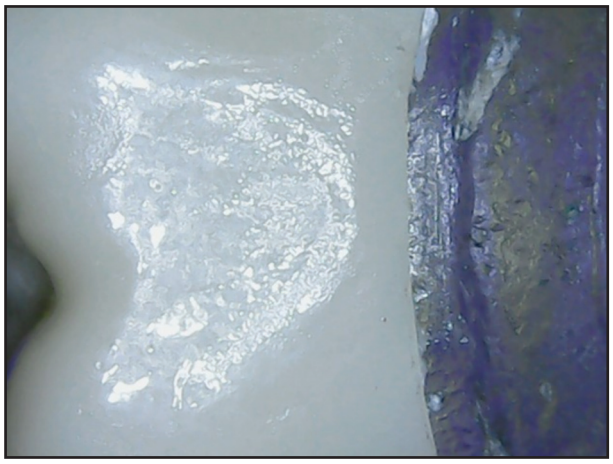

Figure 1 (B): Digital microscopic image for marginal gap of deep chamfer design

DISCUSSION

The introduction of high strength ceramics with superior mechanical properties in thin sections has allowed the clinician to use vertical preparations ending with feather edge finish line for full ceramic restorations. The main advantages of vertical preparations are minimal invasiveness and preservation of the biological structures especially in the cervical area, less amount of loss of tooth structure, impression making is more easier, and high marginal adaptation and integrity [13, 14].

Thus, the present study aimed to evaluate the performance of monolithic zirconia crowns constructed with feather margin through comparing them with the classic deep chamfer margin. The performance was evaluated in-vitro through testing the marginal accuracy of monolithic zirconia crowns constructed with the two marginal configurations.

A deep chamfer finish line design was selected as the control group. This finish line is recommended for all ceramic restorations over shoulder finish line [15, 16]. Its rounded internal angles coupled with its thickness improve the biomechanical performance of posterior single zirconia restoration [9].

Twenty epoxy resin dies were fabricated by impression duplication of the 2 prepared molars. This technique was selected to achieve standardization and permit a reliable comparison between the two different groups [17].

Constructed zirconia crowns were cemented to their corresponding dies using Theracem self-adhesive resin cement which contains 10- methacryloyloxydecyl di-hydrogen phosphate (MDP) that have affinity to metal oxide like zirconium dioxide (ZrO^2) to achieve superior bonding.

In the present study marginal accuracy was evaluated after thermomechanical fatigue, as it is one of the most important aspects affecting long term success of the restoration. Poor marginal fit can result in poor prognosis and finally failure of the restoration [18]. Marginal adaptation was assessed in terms of measuring vertical marginal gap distance.

Regarding the effect of margin design, it was found that deep chamfer margin design recorded statistically significant higher marginal gap mean value (39.64 ± 5.81µm) than feather edge design (32.26 ±3.05µm). The results of the present study agreed with another study [19] in which feather-edge marginal design recorded statistically significant lower marginal gap than chamfer marginal design. This could be due to the fact that the more the margin of the restoration ends with an acute angle,

the smallest the space between the tooth and the restoration margin [10, 11].

The results were also in agreement with another study [20], in which posterior fixed partial dentures prepared by using biological oriented preparation technique (vertical margin design) had a better clinical results over 5-year follow-up, with a low gingival index, a small increase in pocket depth, and a 100% marginal integrity of the surrounding tissues. These results after 5 years supported the using of BOPT that provide promising outcomes.

However the results of the present study were not in agreement with a previous study which found that 0.25 mm vertical finish line recorded statistically significant higher marginal gap mean value than 1mm deep chamfer finish line. However this study used slice finish line (indefinite finish lines) [11].

The present study was not free from limitations. Although using dies guarantee standardization; they lack clinical simulation as they differ from natural teeth. Also, the vertical marginal gap was only measured without relationship with the horizontal gap measurement which would have given more depth to the evaluation of marginal adaptation.

CONCLUSION

Within the limitations of this study, feather edge finish line provides superior vertical marginal adaptation compared to deep chamfer finish line with zirconia monolithic crowns. However, both types of finish lines provide clinically accepted vertical marginal adaptation in comparison to the 120μm proposed by (McLean and Fraunhofer 1971).

RECOMMENDATIONS

In the light of the present study, a minimally invasive preparation designs can be considered in terms of vertical marginal adaptation.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

1. Gerdzhikov I, Radeva E, Uzunov T. Possibilities of improving the shear strength between different type of cement and zirconia ceramics: literature review. J IMAB. 2021; 27: 3557-63.
2. Branco AC, Silva R, Santos T, Jorge H, Rodrigues AR, Fernandes R, et al . Suitability of 3D printed pieces of nanocrystalline zirconia for dental applications. Dent mater. 2020; 36: 442-55.
3. Peampring C, Kengtanyakish S. An experimental study on hydrothermal degradation of cubic-containing translucent zirconia. J Adv Prosthodont. 2020; 12: 265-72.
4. Weig P, Sander A, Wu Y, Felber R, Lauer H/C and Rosentritt M. In-vitro performance and fracture strength of thin monolithic zirconia crowns. J Adv Prosthodont 2018; 10: 79-84.
5. Abdel Raheem I, Abdel Kader S, Abbassy F. The effect of complete and partial contour zirconia coping on the fracture resistance of all ceramic restorations. Alex Dent J. 2018; 43: 22-7.
6. Labno P, Drobnik K. Comparison of horizontal and vertical methods of tooth preparation for a prosthetic crown. J Pre-Clinc Clinc Res. 2020; 14: 25-8.

7. Findakly M, Jasim H. Influence of preparation design on fracture resistance of different monolithic zirconia crowns: a comparative study. J Adv Prosthodont 2019; 11:324-30.
8. Ghodsi S, Mogharrabi S, Jalali S, Ahmadzadeh A, Valizadeh S. Evaluation the effect of different combination of impression and pouring materials on marginal and internal adaptaion of zirconia crowns. J Oral Res. 2020; 9:414-22. J Adv Prosthodont 2019; 11:324-30.
9. Halawani S, Al Harbi S. Marginal adaptation of fixed prosthodontics. IJMDC. 2017; 1:78-84.
10. El Eneen M, El-Naggar G, Taymour M. Marginal accuracy of zirconium reinforced lithium silicate (Vita suprinity) crowns with two marginal designs before and after cementation under thermo mechanical cycling in vitro study. Int. J Appl Dent Sci. 2019; 5: 382-90.
11. K Haggag, M Abbas, H Ramadan. Effect of thermo-mechanical aging on the marginal fit of two types of monolithic zirconia crowns with two finish line designs. ADJ-for Grils. 2018; 5: 121-8.
12. Nawafleh N, Hatamleh M, Elshiyab S and Mack F. Lithium disilicate restorations fatigue testing parameters: A systematic review. J Prosth. 2016; 25: 116–26.
13. Labno P, Drobnik K. Comparison of horizontal and vertical methods of tooth preparation for a prosthetic crown. J Pre-Clin Clin Res. 2020; 14: 25-8.
14. Cagidiaco E, Discpoli N, Goracci C, Carboncini F, Vigolo P. Randomized clinical trial on single zirconia crowns with feather- edge vs chamfer finish lines: four- year results. Int J Perio Resto Dent. 2019; 39: 818-26.
15. Zubaidi Z, Shamma A. The effect of different finishing lines on the marginal fitness of full contour zirconia and glass ceramic cad cam crowns (An in vitro study). J Dent Mater Tech. 2015; 4:127-36.
16. Al Zahrani A. The influence of the cervical finish line design on the fracture resistance of cad/ cam monolithic zirconia crowns. Int J Health Sci Res. 2018; 8:101-10.
17. Aboudorra H, Amr H, El zohairy A, Hafez A, Hassan A. Internal fit evaluation of all ceramic restoration fabricated by two cad/cam milling systems using cone beam ct (CBCT). 2019; 65: 2467-9.
18. Wahsh M, Taha D. In vitro evaluation of the marginal integrity of monolithic ceramic crowns utilizing different machinable blocks fabricated for minimally invasive vertical preparation designs. Egy Dent J. 2020; 66: 2597- 606.
19. Comlekoglu M, Dundar M, Özcan M, Gungor M, Gokce, B, Artunc C, et al. Influence of cervical finish line type on the marginal adaptation of zirconia ceramic crowns. Operative dentistry. 2009; 34:586-92.
20. Panadero R, Pastor B , Loi I, Suárez M , Pelaez J. Clinical behavior of posterior fixed partial dentures with a biologically oriented preparation technique: A 5-year randomized controlled clinical trial. J Prosthet Dent. 2020; 20: 1-7.