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MARGINAL ADAPTATION RELATED TO MARGIN DESIGN OF CAD/CAM CERAMIC CROWNS

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ABSTRACT

Objectives: To ascertain how Feather edge and Chamfer finish line affect the marginal adaption of Zirconia reinforced lithium silicate glass-ceramic (ZLS) and Super transparent multilayered zirconia crowns (STML).

Materials and Methods: Two mandibular molar typodont acrylic teeth with their long axes aligned perpendicular to the surface of the block, stabilized at their apex and inserted in epoxy resin that auto-polymerizes. Simulate all ceramic crown preparation, One with a 0.2mm featheredge margin (F). The other one with a chamfer finish line of 0.5mm (C). A total of 40 monolithic crowns were constructed; 20 crowns from each material: Group ZLS for Zirconia reinforced lithium silicate ceramic (Celtra Duo) CAD/CAM blocks, (Dentsply Sirona), Group STMLZ for Super translucent multilayered zirconia (Katana, Kurary Noritake Japan) (intermediate translucency and strength).

Results: There was a significant interaction between the type of ceramic material and the finish line design on the marginal adaptation as indicated by ANOVA test. Feather edge finish line had better marginal adaptation with STML group than that of ZLS group. On the other hand, Chamfer finish line design for both ceramic groups showed no significant difference on marginal adaptation.

Conclusions: The marginal adaptation was obviously affected by the different margin designs as well as the type of ceramic material used. Feather edge finish line proved to have better marginal adaptation specially with Zirconia ceramics. Chamfer finish line design gave an acceptable marginal adaptation with both Zirconia and Zirconia reinforced glass ceramic.

KEYWORDS: Marginal adaptation, Chamfer FL, Feather edge FL, Celtra, ZLS, Super translucent Zirconia.

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INTRODUCTION

All ceramic restorations are frequently used nowadays allowing the dentist to improve the patient esthetic appearance with excellent tissue response achieved. [1, 2] The use of zirconia ceramics has increased rapidly with the evolution of CAD-CAM technology that results in time savings, patient comfort and high rate of productivity. [3, 4]

The major goal of fixed prosthodontic restorations is to replace lost tooth structures with functional and aesthetically pleasing alternatives without endangering the patients' oral and overall health. [1]

By removing damaged and/or healthy tooth material, a tooth preparation procedure primarily aims to prepare a tooth for restoration. The chosen restorative material and the clinical circumstance both influences how much tooth structure is removed. It must provide enough room to create the ultimate restoration's mechanical strength, appropriate occlusal morphology, and aesthetically attractive appearance. [1, 4]

The long-term clinical effectiveness of single or multiple-unit fixed-partial dentures depends on intimate marginal adaption (FPD). The mechanical and bonding qualities of the materials are what determine how well ceramic restorations perform over the long term. The marginal and internal fit have an impact on it as well. Lack of margin adaptation will cause a gap to emerge between the restoration margin and the tooth, which will cause microleakage and plaque buildup. Thus, there is a higher chance of developing caries, periodontal disease, and endodontic inflammation. These conditions can be harmful to the underlying abutments' health as well as their optical qualities. [6]

The use of shoulder or chamfer finish line for different ceramic materials has been commonly applied for years was great results regarding marginal adaptation of the restorations specially with low strength ceramic materials that necessitate minimum workability thickness as feldspathic porcelain or Lucite glass ceramics, their major disadvantage is being not conservative for the tooth. [3] Vertical preparation (feather edge) finish line is known to be more conservative than shoulder or chamfer preparation design. Feather edge finish line reported some disadvantages as axial over contouring, overhanging margin and lack of good sealing ability. [13] Another challenge was the difficulty to duplicate this thin ill definite margin with a great chance for chipping or fracture of the restorations. With the recent advances in ceramic materials and advances in manufacturing techniques with the small size of diamonds used to mill the ceramic blocks or discs. There is a great chance to fabricate thin edge restoration without fracture or shipping. [5,6]

Increased cement thickness might be the result of poor coping marginal fit, which affects the mechanical durability of Zr-based restorations. Maximal marginal gaps (MG) values have been computed by several writers. Clinically acceptable MG levels in vitro are those between 100 and 150 m. When a marginal mismatch cannot be seen with the naked eye or is undetectable by a dental probe, it can be accepted. Clinical testing has shown that it is exceedingly challenging to identify an MG of less than 80 m. [4, 9]

In the literature, two primary fit evaluation techniques are discussed. At first, a specimen or replica is cut into sections, and then a microscopic examination is carried out. In the second, a non-destructive approach, only exterior gap measurements are carried out. When evaluating the marginal fit of restorations using conventional methods, which can only do so in two dimensions, the gaps between the restoration and the die are frequently checked using a microscope at 4–24 sites in various sections. [10, 14]

MATERIALS AND METHODS

Materials

Full coverage crowns were made from two materials: zirconia reinforced lithium silicate (ZLS) Celtra due* chemically composed of SiO_2, Li_2O, ZrO_2, P_2O_5, Al_2O_3, K_2O, CeO_2, pigments, and super translucent multilayered zirconia (Katana STML)** chemical composition.

Crowns were cemented by Duo-Link Universal™ dual-cure resin luting cement. Chemical ingredients of luting cement; (50-70% Glass Filler, 10-30% Bisphenol A Diglycidylmethacrylate, 10-30% Triethylene Glycol Dimethacrylate and 5-10% Amorphous Silica).

Methods

A total number of 40 crowns were divided into 2 groups according to material of fabrication (n=20); Group (K): Super translucent Multilayered Zirconia (Katana) and Group (C): Reinforced lithium Silicate (Celtra due).

Each group was split up further into two smaller groups according to margin design Chamfer (c) or feather edge finish line (f) (n=10).

Two mandibular molar typodont acrylic teeth were immersed in auto-polymerizing epoxy resin and stabilized at their apex, with their long axes orientated perpendicular to the surface of the block below their cementoenamel Junction. The teeth were assigned into two groups according to margin designs; namely:

Chamfer group (c): 1.5 mm occlusal reduction, 1 mm reduction along the axial walls, 0.5 mm chamfer finish line, and convergence angle of 6° finish line thickness checked by using a digital caliper.

Feather edge (f): 1.5 mm occlusal reduction, 1 mm reduction along the axial walls 0.2 mm feather edge finish line, and convergence angle of 6°.

A modified dental surveyor *** was used to ensure standardized tooth preparations. A turbine handpiece was held by the dental surveyor's vertical arm. So, to transfer the bur's taper to the axial walls of the tooth, the long axis of the bur was measured using a protractor parallel to the long axis of the typodont tooth.

The occlusal and axial reduction was made first by a green ring rugby milling bur (Komet Dental, ISO8368314023, LOT 189567, Lemgo, Germany) and then a red ring rugby milling bur (Komet Dental, ISO 806314012, LOT 624719). 0.2mm feather edge finish line and convergence angle of 6°. The cervical preparation margins were placed in cementum-dentin following the cementum-enamel junction (CEJ) using first a coarse grit tapered milling bur (Komet Dental, ISO 862314016, LOT 241757) and then a red ring tapered milling bur (Komet Dental, ISO 806314012, LOT 53167).

Dies fabrication

Each prepared typodont tooth was duplicated by using silicon index and epoxy resin **** to produce two master dies. The epoxy resin dies were allowed to be completely set for 24 hours, then removed. Each master die was duplicated to complete the group count (20). The duplicated dies were inspected for fine details and compared to the master die after that, each given serial number as we did for fabricated crowns.

Crowns fabrication

The master dies were scanned for each group using CEREC AC system (Sirona, Germany after scanning the epoxy dies with Omnicam. Ceramic crowns with predefined dimensions were created using CEREC 3D Software version 4.3.

* Dentsply, United States

** Kuraray Noritake, Japan.

*** Paraline, Dentaurum, Ispringen, Germany

**** Kimapoxy 3D 150, CMB, Egypt

The master dies were scanned for each group using the CEREC AC system (Sirona, Germany) after scanning the epoxy resin dies with Omnicam. Ceramic crowns with predefined dimensions were created using CEREC 3D Software version 4.3.

The crowns were ground using a Cerec MCXL milling machine. Celtra Duo crowns were crystallized in a suitable ceramic furnace at 840 °C (Programat CS4, Ivoclar Vivadent, USA). Crowns were cleaned with a steam cleaner, Celtra glaze (Dentsply Sirona, United States) was mixed with liquid and applied to the surface using a brush, and glaze firing was completed in a compatible ceramic furnace before polishing (Programat CS4, Ivoclar Vivadent,).

Milling of the (Katana STMZ, Kuraray Noritake) 14 mm was performed by a five-axis dental milling machine inLab MCX5(Dentsply Sirona, Germany). The crowns were milled with an approximate 20-25% oversize. To determine the precise amount of oversize required during milling to account for the shrinkage caused by sintering, the blank is identified with a barcode and a specified enlargement factor.

To restore zirconia crown restorations to their previous size, strength, and color, sintering was performed using a sintering furnace (In Fire HTC Speed Furnace, Sirona, Bensheim, Germany) at 1540ºC. The sintering furnace's built-in software was used to carry out the cooling routine for zirconia crowns.

The crowns were cleaned by air after being checked for deformity and dirt. After cleaning crowns were polished and smoothed by diamond impregnated silicone instrument121and polishing paste (pearl surface Z) with a maximum rotational speed of 15,000 rpm due to minimum thickness of zirconia. Careful attention was taken to the marginal area to avoid chipping.

Crowns adhesive cementation

Each group of crowns was adherent-cemented following the manufacturer's instructions.

Sandblasting of the fitting surfaces of the crowns STML zirconia (Katana) was carried out using 50-µm aluminum oxide at a 1.5 bar with a chairside micro-etcher 10 mm distance for 20 seconds. Sandblasted crowns cleaned by ultra-sonic bath then dried.

Finished crowns were cemented to the corresponding teeth using Duo-Link Universal™ dual-cure resin cement. The cement was applied after the application of a uniform layer of Z-Prime Plus directly into the fitting surfaces of the finished crowns.

The inner faces of ZLS (Celtra Duo) crowns were etched with 5% hydrofluoric acid for 30 s (before cementation., then crowns were silanized (silane coupling agent Monobond S, 60 s, Ivoclar-Vivadent).

After a thorough cleaning, the crowns were dried with oil-free air. After that, the surfaces were silanized using a primer (Porcelain Silane, Ultradent Products, UT, USA) and allowed to react for 60 seconds.

Duo-Link Universal™ dual-cure resin cement was applied using the automix tip to the fitting surface of the crowns, which were then static finger pressured onto the appropriate dies and axially loaded for 10 minutes with a fixed load of 5 kg using a specially constructed load applicator, with the cement drying for 20 seconds per surface.

The crowns first received a 2-second light curing exposure. A scaler was used to remove any extra cement, and each side underwent a 20-second light cure. After cementation, the dies were cleaned of any left-over cement and let to completely set for 24 hours in distilled water.

Measurements

For measurements of the cervical vertical marginal gap. Four readings for each surface at predetermined equidistant points were taken using a Stereo microscope (SZ- PT, Olympus, Japan) at a magnification of 13.5X. After that, images were uploaded to the computer system for examination. Using the image analysis tool Image J, 1.46r, NIH, USA, the vertical gaps between the cervical border of the crown and the outer end of the finish line were automatically calculated. Using the same focus as for the photos of the specimens, a calibration scale was recorded. By specifying the known distance on the measuring scale picture in micrometers in Pixel units, the marginal gap of the specimen was measured using the software Image, and the resulting pixel/micrometer relationship could then be universally applied to all photos. Therefore, the measurements were carried out at 16 points for each crown, figures (1) and (2). Next, for statistical analysis, the mean vertical gap (in microns) for each specimen was determined and tabulated.

RESULTS

Descriptive statistics for marginal gap values were presented in table (1) and figure (3). Results of two-way ANOVA presented in table (2), showed there was a significant interaction between the type of ceramic material and the finish line design on the marginal gap ($p<0.001$). A comparison of simple main effects presented in table (3) showed that there was no significant difference between ZLS and STML samples with a chamfer finish line ($p=0.964$). However, for the feather edge finish line, ZLS samples had a significantly higher marginal gap than STML samples ($p<0.001$). In addition, it was found in both materials that samples with a chamfer finish line had a significantly higher marginal gap than feather edge samples ($p<0.001$). Mean and standard deviation values for the marginal gap in different groups were presented in figures (4) and (5).

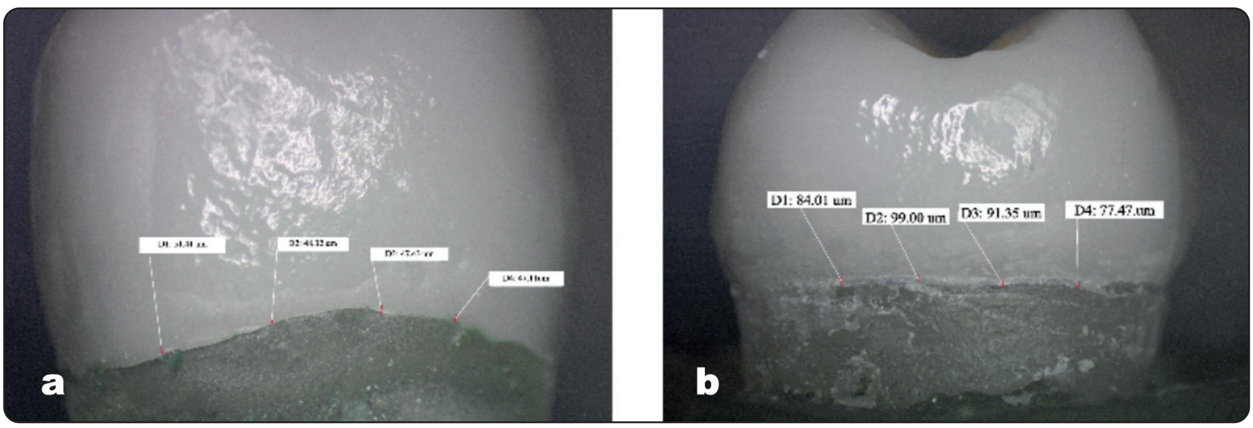


Fig. (1): STML with feather edge finish line (a) and Chamfer Finish line (b)

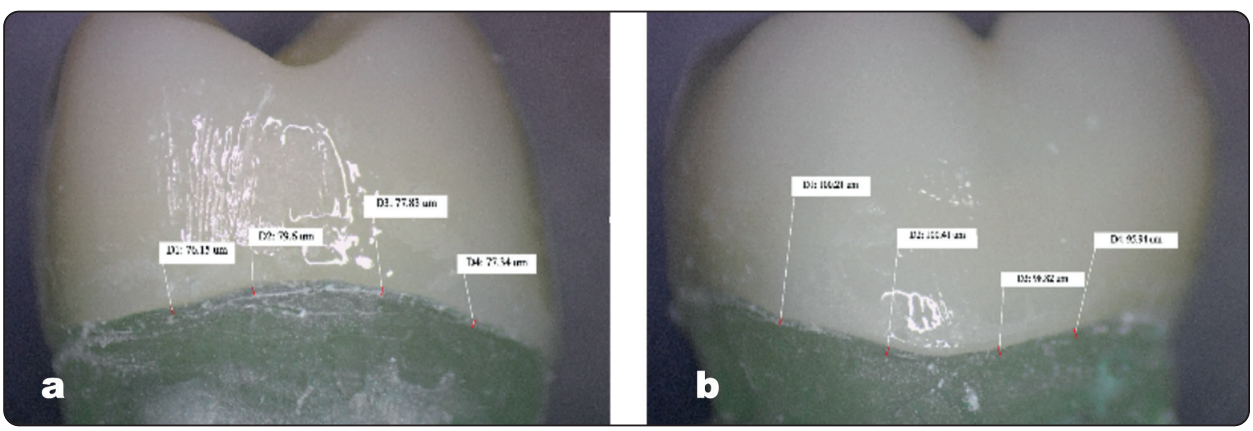


Fig. (2): ZLS with feather edge finish line (a) and Chamfer Finish line (b)

TABLE (1): Descriptive statistics for marginal gap (μm)

Material	Finish line	Mean	95% CI		SD	Median	IQR
			Lower	***Upper***			
ZLS	***Chamfer***	98.59	95.73	101.46	4.62	101.11	8.32
	Feather	78.34	76.97	79.71	2.21	78.13	2.59
STML	***Chamfer***	98.67	95.70	101.65	4.80	97.54	5.51
	Feather	49.04	46.67	51.41	3.82	47.95	4.72

95%CI= 95% confidence interval for the mean; SD=standard deviation; IQR=interquartile range

TABLE (2): Two-way ANOVA test results

Parameter	Sum of squares	df	Mean square	Partial eta squared	f-value	p-value
Material	2134.23	1	2134.23	0.788	133.60	**<0.001***
Finish line	12208.64	1	12208.64	0.955	764.26	**<0.001***
Material*Finish line	2157.97	1	2157.97	0.790	135.09	**<0.001***
Error	575.08	36	15.97			

****significant (p<0.05)***

TABLE (3): Comparisons of simple main effects

Finish line	Marginal gap (μm) (Mean±SD)		p-value
	ZLS	STML	
Chamfer	98.59±4.62	98.67±4.80	0.964
Feather	78.34±2.21	49.04±3.82	<0.001*
p-value	<0.001*	<0.001*	

****significant (p<0.05)***

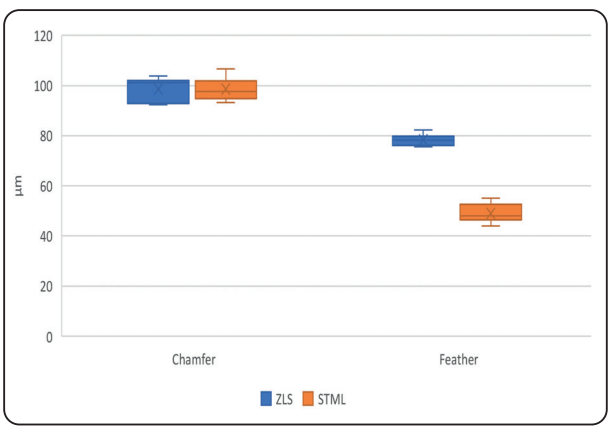
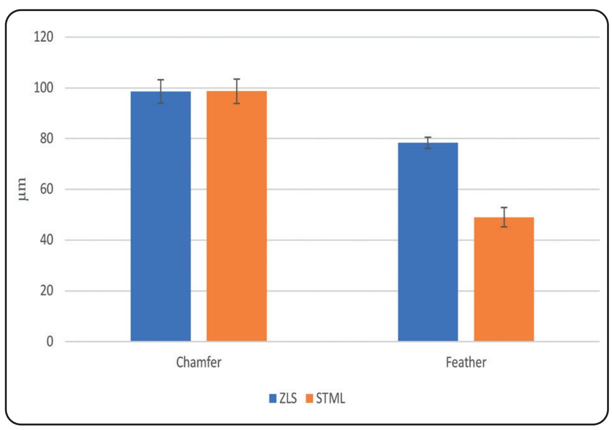


Fig. (3): Box plot showing marginal gap (μm) values in different groups



Fig/ (4): Bar chart showing mean and standard deviation values of marginal gap (μm) values in different materials

DISCUSSION

Achieving acceptable function, accuracy, and aesthetics has always been the foundation for clinical success in restorative and prosthetic dentistry. These objectives depend on a variety of elements, including the condition of the periodontal tissues, the precision of the abutment, and the absence of fracture. [1]

Since it impacts its life and, in turn, the effectiveness of the prosthetic restoration, the size of the marginal gap is a key element for the restoration's quality. The long-term success of restorations has been thought to be significantly influenced by fit and adaptability between the tooth and the restoration. [2] Clinically acceptable marginal gap values for cemented restorations have been found in earlier investigations to range from 100 to 200 m. [3] Excessive marginal gaps can harm periodontal tissues, and promote the growth of recurrent caries or pulp lesions, increase dental plaque retention, and cause bone resorption. [4]

The final lines for all-ceramic crowns that are bonded on prepared teeth might be chosen to be horizontal. For all-ceramic crowns, recommended finish line thickness has varied from 0.5 to 1.0 mm. (5) Recently, in vitro testing of feather edge margins for zirconia crowns as a less invasive preparation design with satisfactory clinical efficacy. [6]

It has been suggested to employ vertical preparation for zirconia restorations, particularly when using periodontally compromised teeth as abutments for fixed prostheses. Additionally, for teeth that have undergone endodontic treatment, for teeth that are important in children, and for carious teeth in the cervical third of the clinical crown, vertical preparations may be a less invasive option than the horizontal margin. [7]

In a study done by Vigolo et al. [8] on 46 teeth, 23 teeth with vertical finishing lines and 23 with horizontal finishing lines concluded that the marginal fit of single-unit zirconia crowns manufactured with vertical finishing lines was comparable to the marginal fit of single-unit zirconia crowns made with the more common horizontal finishing line. Ceramic single crowns made of zirconium oxide were created using CAD/CAM technology. Glass ionomer cement was used to bond the zirconia crowns. Using a microscope with a 50x magnification, marginal gaps in vertical planes were measured for each crown using a total of four landmarks for each tooth. [9]

The ideal CAD/CAM material to utilize with vertical preparations or feather-edge margins, however, is not well covered in the literature. This in vitro study's goal was to demonstrate a minimally invasive prosthetic technique when a complete crown was needed by evaluating the marginal adaption of several monolithic ceramic crowns glued to feather edge margins.

It is expected that the in-vitro study will provide uniform circumstances for the preparation design, imprint method, or experimental execution, resulting in assessments that may be more accurate. In addition, the in vitro results should be carefully considered in contrast to in vivo research because of the evaluation constraints that do not allow them to accurately mirror clinical settings, but they may be useful in providing important data and guidance for clinical applications. [10]

For the sake of standardization, all of the procedures in our research were completed by the same operator.

Samples of the present study were made of epoxy resin material which the test specimens were cemented for investigating their marginal adaptation since its modulus of elasticity is like the reported modulus of human dentin and they are easily available, and their dimensions can be standardized. [11] It has been discovered that using excised genuine teeth as specimens simulates clinical settings more accurately than resin abutments. However, it is challenging to standardize genuine teeth due to several characteristics, including age, anatomical variances, size, form, and time spent in storage following extraction.[12,13]

It was determined how well the crowns' marginal adaptation performed under a stereomicroscope. Even while direct viewing with external measurements, as was done in this work, has the advantage of being nondestructive and amenable to clinical practice, it is difficult to repeat the measurements from the same angle and discern the genuine marginal gap apart from its projection. [14] The measurement of the vertical cervical marginal gap was chosen as the method most usually used to assess how accurately a restoration fit. [15,16] The present study's findings showed that super translucent multilayered zirconia crowns with feather edge (group STML) showed the lowest mean marginal gap value (49.04±3.82) with a statistically significant difference compared to other test groups. Followed by ZLS with feather edge restorations with a marginal gap of (78.34±2.21), while the chamfer finish line subgroups for each material showed insignificant differences for mean marginal gaps.

Several factors may have an impact on the CAD/CAM materials' marginal accuracy, including scanning method, software, and milling procedure. Carbide milling tools were used to mill zirconia blocks while diamond tools were used for celtra duo blocks. Also, the zirconia blank was dry milled while celtra blocks were wetly milled which could explain the difference in marginal gap values recorded. In addition, the pre-sintered state is less hard than other ceramic materials, it can be milled with greater ease and less pressure offering the advantage of producing a thin edge design due to its excellent strength, toughness, and ease of milling. [17]

In addition, variations in mean gap values recorded for both types of materials tested could be due to the different number of milling axis of both systems (4- axis milling unit of the Cerec MCXL and the 5-axis unit of the Cerec InlabMCX5. Bosch et al. [18] stated that five-axis milling produces high trueness and permits a more effective milling of surfaces close to the insertion axis and a better outcome can be produced with steep walls and small angles. Furthermore, Ender et al [19] reported a higher accuracy of scans obtained from In Eos X5 scanner in comparison to eight different intra-oral scanners.

The mean marginal gap for the feather edge finish line in our study was less than the chamfer finish line. This conclusion supports the findings of the earlier investigation, which found that the feather edge preparation design had the least significant disagreement. [20] and coincides with the recent findings [21]

Although there were statistical differences between the four groups in the current study, the marginal gap values of monolithic ceramic crowns were all within the range of clinically acceptable values.

CONCLUSION

The following conclusion may be drawn within the constraints of the current study:

1. Margin designs significantly affect the marginal adaptation of all-ceramic crowns.
2. STML zirconia crowns showed better marginal adaptation than CeltraDuo in the feather edge group.
3. Both ceramic materials STML and ZLS had no significant difference on marginal adaptation with chamfer finish line.

REFERENCES

1. Hickel R, Peschke A, Tyas M, Mjör I, Bayne S, Peters M, et al. FDI World Dental Federation: clinical criteria for the evaluation of direct and indirect restorations—update and clinical examples. Clinical oral investigations. 2010;14(4):349-66.
2. Lins L, Bemfica V, Queiroz C, Canabarro A. In vitro evaluation of the internal and marginal misfit of CAD/CAM zirconia copings. J Prosthet Dent. 2015;113(3):205-11.

3. Renne W, McGill ST, Forshee KV, DeFee MR, Mennito AS. Predicting marginal fit of CAD/CAM crowns based on the presence or absence of common preparation errors. J Prosthet Dent. 2012; 108(5):310-5.

4. Goodacre CJ, Campagni WV, Aquilino SA. Tooth preparations for complete crowns: an art form based on scientific principles. J Prosthet Dent. 2001;85(4):363-76.

5. Souza ROA, Özcan M, Pavanelli CA, Buso L, Lombardo GHL, Michida SMA, et al. Marginal and internal discrepancies related to margin design of ceramic crowns fabricated by a CAD/CAM system. Journal of Prosthodontics: Implant, Esthetic and Reconstructive Dentistry. 2012;21(2):94-100.

6. Poggio CE, Dosoli R, Ercoli C. A retrospective analysis of 102 zirconia single crowns with knife-edge margins. J Prosthet Dent. 2012;107(5):316-21.

7. Schmitt J, Wichmann M, Holst S, Reich S. Restoring severely compromised anterior teeth with zirconia crowns and feather-edged margin preparations: a 3-year follow-up of a prospective clinical trial. Int J Prosthodont. 2010;23(2):107-9.

8. Vigolo P, Mutinelli S, Biscaro L, Stellini E. An In Vivo Evaluation of the Fit of Zirconium-Oxide Based, Ceramic Single Crowns with Vertical and Horizontal Finish Line Preparations. J Prosthodont. 2015;24(8):603-9.

9. Tinschert J, Natt G, Mautsch W, Spiekermann H, Anusavice K. Marginal fit of alumina-and zirconia-based fixed partial dentures produced by a CAD/CAM system. Operative dentistry. 2001;26(4):367-74.

10. Gonzalo E, Suarez MJ, Serrano B, Lozano JF. Comparative analysis of two measurement methods for marginal fit in metal-ceramic and zirconia posterior FPDs. Int J Prosthodont. 2009;22(4):374-7.

11. Belser UC, Mericske-Stern R, Bernard JP, Taylor TD. Prosthetic management of the partially dentate patient with fixed implant restorations Note. Clinical Oral Implants Research: Chapter 8. 2000;11:126-45.

12. Alghazzawi TF, Lemons J, Liu P-R, Essig ME, Janowski GM. The failure load of CAD/CAM generated zirconia and glass-ceramic laminate veneers with different preparation designs. J Prosthet Dent. 2012;108(6):386-93.

13. Mello C, Santiago Junior JF, Galhano G, Quinelli Mazaro JV, Scotti R, Pellizzer E. Analysis of vertical marginal adaptation of zirconia fixed dental prosthesis frameworks fabricated by the CAD/CAM system: a randomized, double-blind study. Int J Prosthodont. 2016;29:157–60.

14. Gassino G, Monfrin SB, Scanu M, Spina G, Preti G. Marginal adaptation of fixed prosthodontics: a new in vitro 360-degree external examination procedure. Int J Prosthodont. 2004;17(2):218-23.

15. Wolfart S, Wegner SM, Al-Halabi A, Kern M. Clinical evaluation of marginal fit of a new experimental all-ceramic system before and after cementation. Int J Prosthodont. 2003;16(6):587-92.

16. Ji MK , Park JH, Park SW, Yun KD, Oh GJ, Lim HP, Evaluation of marginal fit of 2 CAD-CAM anatomic contour zirconia crown systems and lithium disilicate glass ceramic crown. J Adv Prosthodont. 2015;7:271-7

17. Park S-H, Lee K-B. A comparison of the fidelity between various cores fabricated with CAD/CAM systems. J Korean Academy Prosthodont. 2008;46(3):269-79.

18. Bosch G, Ender A, Mehl A. A 3-dimensional accuracy analysis of chairside CAD/CAM milling processes. Journal Prosthet Dent. 2014;112(6):1425-31.

19. Ender A, Zimmermann M, Mehl A. Accuracy of complete- and partial-arch impressions of actual intraoral scanning systems in vitro. Int J Comput Dent. 2019;22(1):11-19.

20. Jacobs MS, Windeler AS. An investigation of dental luting cement solubility as a function of the marginal gap. J prosthet Dent. 1991;65(3):436-42.

21. Almahdy RM, Mandour MH, El Sharkawy ZR. Marginal accuracy of monolithic zirconia crowns with vertical and horizontal margin configurations after thermomechanical fatigue. ADJ-for Girls. 2022;9 (1):55-60.