EGYPTIAN
DENTAL JOURNAL
www.eda-egypt.org

Vol. 69, 583:592, January, 2023

Print ISSN 0070-9484 • Online ISSN 2090-2360

Fixed Prosthodontics and Dental Materials

Submit Date : 22-10-2022 • Accept Date : 25-11-2022 • Available online: 1-1-2023 • DOI : 10.21608/edj.2022.169844.2308

ASSESSMENT OF INTERNNAL ADAPTATION OF CAD CAM ALL CERAMIC CROWNS WITH TWO DIFFERENT MARGIN DESIGNS

Omayma Tantawy Sayed * Amer H. El-Bolok ** *and* Shams Waaz Amgd***

ABSTRACT

Aim: This study examined the effect of cervical finish line preparation on the internal adaptation of all-ceramic crowns produced, using CAD CAM technology with two fabricated materials: IPs Emax and Zirconia-reinforced lithium silicate (Celtra Duo).

Methods: Two intact human premolars were collected with similar preparation dimensions, except for a (1.00 mm) on the margin. For sample standardization, 40 epoxy replicas of prepared premolar teeth were produced. Deep chamfer (DC group, n = 20) and knife-edge (KE group, n = 20) finish lines were used to split samples. Each group was divided into two subgroups according to fabricated material. Subgroup 1: lithium di silicate ceramic (n=10) and Subgroup 2: lithium silicate reinforced with zirconia (n=10). All crowns were CAD/CAM-made. All samples were aged by thermo-cycling after being bonded to a tooth, and the internal adaptation was measured using a stereomicroscope.

Results: The findings demonstrated an increase in the internal adaptation between vertical preparation (127.7±8.6) and deep chamfer (109.9±6.4), regardless of the material. In addition, regardless of methodology, the difference between E-max (119.6±16) and Celtra (118±5.7).

Conclusions: Vertical preparation may be an alternative to horizontal preparation and more conservative to sound tooth structure throughout the fabrication of fixed abutments to give a less intrusive option.

KEY WORDS: Internal adaptation, Vertical preparation, CAD/CAM technology, Zirconia reinforced lithium silicate (Celtra Duo), Epoxy.

* Post Graduate Student, Fixed Prothodontic Department, Faculty of Dentistry, Minia University, Assistant Lecturer, Faculy of Dentistry, Nahda University, Beni-Suef, Egypt.

** Professor of Oral Pathology Department, Chairman of Oral Pathology Department department, Faculty of Dentistry, Minia University, Egypt

*** Associate Professor of Fixed Prosthodontics, Fixed Prothodontis Department, Faculty of Dentistry, Minia University, Egypt.

INTRODUCTION

Tooth preparations for fixed prosthetic restorations can be done in different ways, basically two kinds: preparation with a defined margin the so-called horizontal preparation and vertical preparation with an indefinite margin. The later used mainly for prosthesis of periodontally affected teeth. The difference between horizontal and vertical preparations is that in the first ones the margin positioned by the dentist and leaves a well-defined line on the tooth, which is then replicated in the impression and on the working model. This is probably the reason that has made prosthodontists prefer horizontal preparations. For vertical preparations, the margin is positioned based on the gingival tissue information, and due to the absence of a well-defined line, there are difficulties in obtaining a good esthetic result, there are risks of distortion of the metallic margin during porcelain firing and functional load. Polycrystalline zirconium dioxide ceramics and lithium disilicate glass ceramics are now mainly used in restorative indirect restorations for their optimal mechanical and esthetic characteristics.[1,2] The group of glass ceramics still provides the best translucency and esthetic qualities. Although new-generation lithium disilicatebased ceramics have improved mechanical properties with a flexural strength of 300 to 400 MPa, they are only recommended for singleunit restorations and short-span bridges in anterior regions.[3] This group of ceramics allow better adhesive link to the tooth structure using adhesive resin cement enabling clinicians to perform more conservative preparation designs. [4]

Among others, a new group of machinable ceramics has recently been introduced: zirconia-reinforced lithium silicate ceramics. [5]

These materials offer mechanical properties ranging from 370 to 420 MPa. Thus, they are comparable with the clinically well-proven lithium disilicate glass ceramics. The improved strength and reliability are reached by the addition of 8 to 10% by weight zirconium oxide. Moreover, it has improved esthetic and bond strength compared with zirconia. [6] For successful restorations, the concept of minimally invasive preparation is essential. [7]

The ultimate goal of reconstructive dentistry is to obtain excellent esthetic results while simultaneously respecting the biological structures. Currently, both clinicians and technicians have an access for different materials and procedures that enable esthetics and function to be created in a predictable and simpler ways. All-ceramic restorations and new adhesive systems enable greater preservation of remaining hard tooth structures particularly regarding single restorations. [8 .9] The vertical preparation can preserve a maximum of sound tooth structure as it provides the most acute marginal restoration. [10]

MATERIALS & METHODS

Two extracted premolar teeth were retrieved from the maxillofacial surgery clinic of the Faculty of Dentistry at Minia University for objectives including diabetes, loose teeth, orthodontics, and periodontal disease. After informing patients, their agreement was be obtained prior to utilizing their teeth in a scientific investigation.

Two designs were developed based on preparations for the cervical finish line (deep chamfer finish line in horizontal preparation and knife-edge finish line in vertical preparation). The same researcher finished the preparations using a new diamond bur in a water-cooled high-speed handpiece (Apple dental, Hunan Jinme, Hong Kong).

The dimensions of the preparations were identical with the exception of the crown margin, where one group had a 1.00 mm deep chamfer and the other group had a knife-edge. A 2.0 mm occlusal reduction, a 1.2–1.5 mm axial reduction, a total convergence angle of 6 degrees, and rounded line angles.

Deep chamfer tooth preparation

The tooth was prepared according to the guidelines for preparing all ceramic crown restorations. The prepared teeth met the following specifications: a 1mm deep chamfer finish line, a 0.5mm occlusal to cementoenamel junction, a 5mm occluso-axial height, a 2mm occlusal reduction, and 6-degree axial wall conversions. Each was prepared by tapered rounded end stone (Medit, I750, Korea). The occlusal preparation was carried out in accordance with the anatomical contour.

Vertical tooth preparation

Using diamond drills, the following vertical tooth preparation procedures were carried out (Sweden & Martina S.p.A., Via Veneto 10, 35020 Due Carrare (PD), Italy). The mesiodistal zone prepared with a coarse-grit thin flame drill (FG862/020C). In order to prepare the occlusal surface, the tapered drill (FG856/018) was aligned with the cusp angle. From the tip of the cusp to the enamel-dentin border, a 45° vestibular and lingual preparation was produced. With the coarse-grit drill, the vestibular and palatal supragingival axial reduction was completed. After reducing the circumference of the teeth, go to the subsequent procedure,progressively verticalize the drill to line the vestibular preparation with the axial walls. Red-ringed drills (fine) and, if necessary, yellow-ringed drills (coarse) were utilized to finish tooth preparation (super fine). In the cervical region where the crown margin will be positioned, the surface was polished.

Samples of epoxy were created in an effort to address problems encountered during tooth preparation, including as fractures and enamel hypomineralization.

Based on the kind of cervical finish line preparation, all samples were separated into two groups: deep chamfer (DC group, n = 20) and knife-edge (KE group, n = 20). Each group will then split into two subgroups (ten for each). Sub group1: lithium di silicate ceramic (n =10), and Subgroup 2: lithium silicate reinforced with zirconia (n=10).

Samples of epoxy were created in an effort to address problems encountered during tooth preparation, including as fractures and enamel hypomineralization. Using a silicon impression media (Reprisil 22 N, dent-e-con, Baden-Württemberg, Germany), the prepared teeth were imprinted. In accordance with the manufacturer's instructions, the material was mixed and put into a metallic perforated cylinder tray sized according to the average size of a tooth. Then, in accordance with the manufacturer's instructions, powder and liquid epoxy resin (Kemapoxy150, CMB international group, Giza, Egypt) were combined and poured into the mould.

For cementation of both groups, dual-cure self-adhesive resin cement (G-CEM capsule, GC Co., Japan) was applied using an auto mixing gun to the fitting surface of restorations. The cement-retained crowns were subjected to thermocycling (Robota automated thermal cycle; BILGE, Turkey) with water serving as the transfer medium and cyclic loading.

Using a specialised cementation device, 5 kg (50 N) of force was delivered to the occlusal surface of each restoration after each crown was cemented to its matching tooth. For cementation by resin cement (self-adhesive)

There were 500 thermal cycles with fluctuating hot and cold temperatures. Each water bath lasted for 25 seconds, followed by a 10-second interval. The lowest temperature recorded? (5^0C), and the highest temperature reached 55^0 degrees Celsius, most likely in an effort to mimic intraoral timings.

To examine the margins, all samples were sectioned and examined at a variety of magnifications and stereomicroscopes. Determination of the accuracy of the internal adaptation was performed and measured as the maximum distance between the inner surface of the labial wall of crown and the

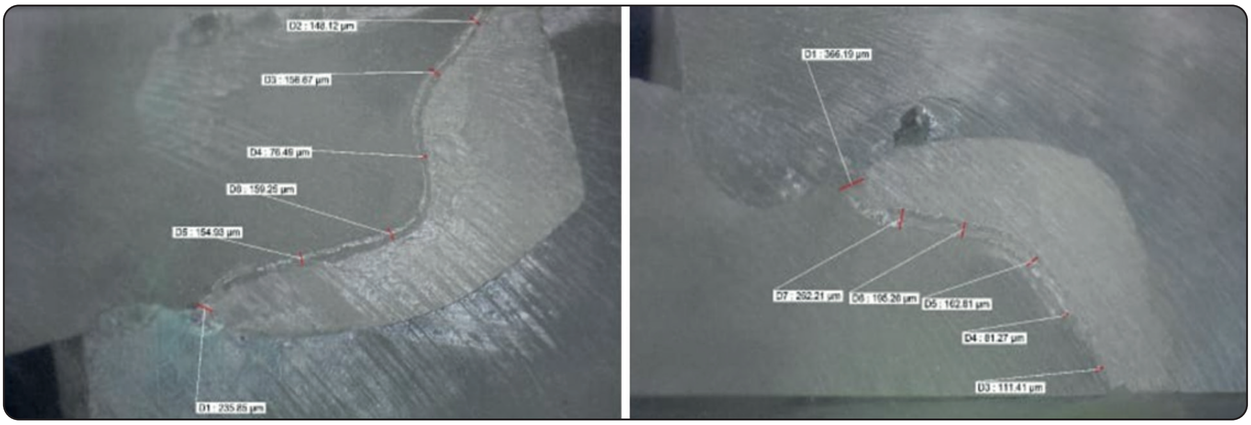

Figure (1, 2): Tested sample under examination.

outer surface of the prepared tooth at different fixed locations. **Figure (1, 2)**

Using the software (Omnimet, Buehler, USA) for image analysis measurements were also made on both sections (bucco lingual and mesiodistal). as the greatest distance between the tooth preparation's line and the crown's margin.

For comparisons between classes, a one-way analysis of variance (ANOVA) was conducted, whereas a two-way analysis of variance (ANOVA) was used for comparisons among subgroups. Two related sample groups were compared using a paired sample t-test. Using a t-test for independent samples, samples from two unrelated groups were compared

RESULTS

Determining the internal adaptation between different techniques regardless the material.

Comparison of internal adaptation between different techniques regardless the material showed significant increase of internal adaptation in vertical preparation (127.7±8.6) compared with deep chamfer (109.9±6.4), p value < 0.001. **Table (1), Figure (3)**

TABLE (1): Comparison of internal adaptation between different techniques regardless the material

		[redacted]
Internal adaptation	*Range* *Mean ± SD*	

: Significant difference at P value < 0.05

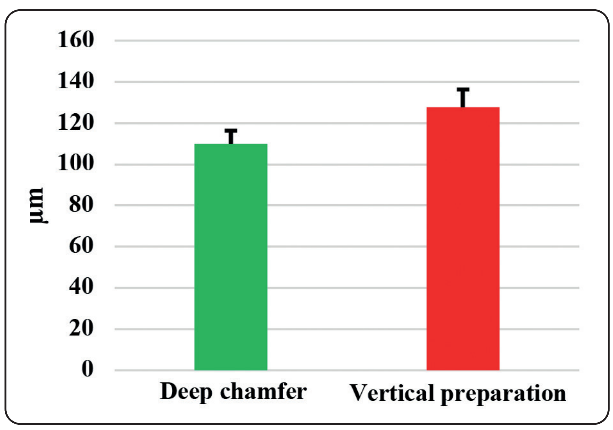

Fig. (3): Bar chart representing comparison of internal adaptation between different techniques regardless the material.

Determining the internal adaptation between different materials regardless the technique.

Comparison of internal adaptation between different material regardless the technique showed insignificant difference as it was in E-max (119.6±16) and in Celtra (118±5.7), p value = 0.764. **Table (2), Figure (4)**

TABLE (2): Comparison of internal adaptation between different materials regardless the technique.

		Celtra	E-max	P value
		N=10	N=10	
Internal adaptation	Range Mean ± SD	(109-129) 118±5.7	(96.8-144.8) 119.6±16	0.764

Significant difference at P value < 0.05

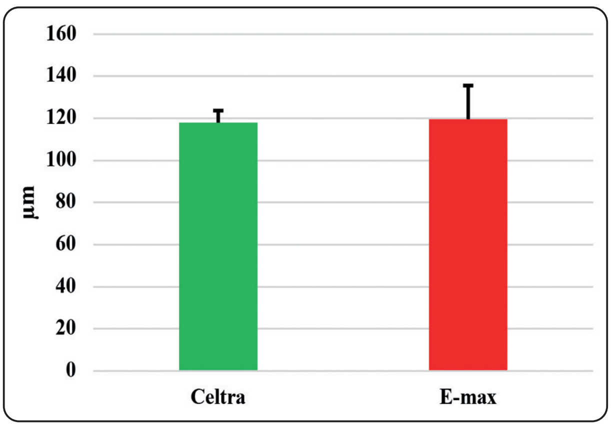

Fig. (4): Bar chart representing comparison of internal adaptation between different materials regardless the technique.

Determining the internal adaptation between different techniques using celtra material.

Comparison of internal adaptation between different techniques using celtra material, showed significant increase of internal adaptation in vertical preparation (122.1±4.7) compared with deep chamfer (113.9±3.3), p value = 0.013. **Table (3), Figure (5)**

TABLE (3): Comparison of internal adaptation between different techniques using celtra material.

Celtra		Deep chamfer	Vertical preparation	P value
		N=5	N=5	
Internal adaptation	Range Mean ± SD	(109-117.9) 113.9±3.3	(117.9-129) 122.1±4.7	0.013*

: Significant difference at P value < 0.05

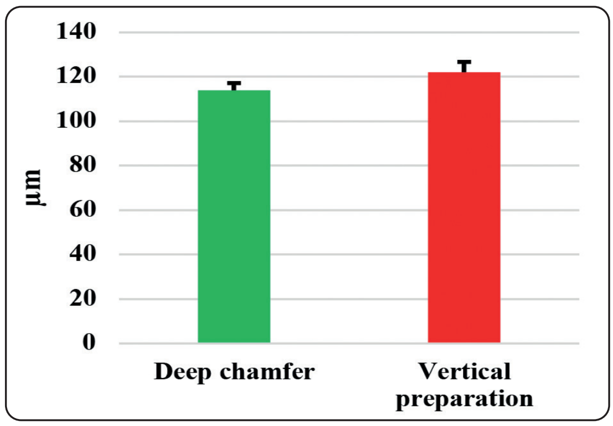

Fig. (5): Bar chart representing comparison of internal adaptation between different techniques using celtra material.

Determining the internal adaptation between different techniques using E-max material.

Comparison of internal adaptation between different techniques using E-max material, showed significant increase of internal adaptation in vertical preparation (133.3±8.2) compared with deep chamfer (105.9±6.5), p value < 0.001. **Table (4), Figure (6)**

TABLE (4): Comparison of internal adaptation between different techniques using E-max material

E-max		Deep chamfer N=5	Vertical preparation N=5	P value
Internal adaptation	Range	96.8-112.3	122.6-144.8	<0.001*
	Mean ± SD	105.9±6.5	133.3±8.2	

: Significant difference at P value < 0.05

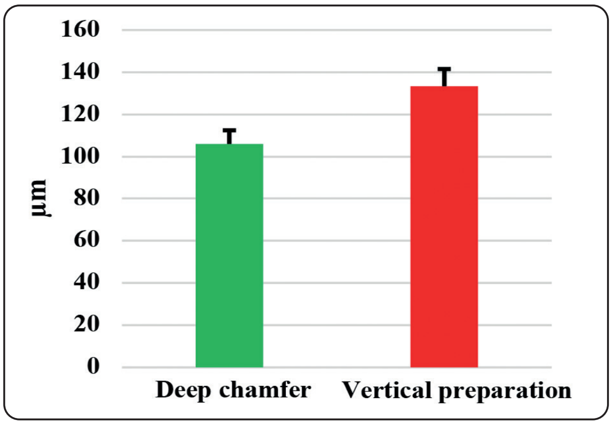

Fig. (6): Bar chart representing comparison of internal adaptation between different techniques using E-max material.

Determining the internal adaptation between different materials using deep chamfer technique.

Comparison of internal adaptation between different material using deep chamfer technique showed significant increase of internal adaptation in celtra (113.9±3.3) compared with E-max (105.9±6.5), p value = 0.040. **Table (5), Figure (7)**

TABLE (5): Comparison of internal adaptation between different materials using deep chamfer technique.

Deep chamfer		Celtra N=5	E-max N=5	P value
Internal adaptation	Range	(109-117.9)	(96.8-112.3)	0.040*
	Mean ± SD	113.9±3.3	105.9±6.5	

: Significant difference at P value < 0.05

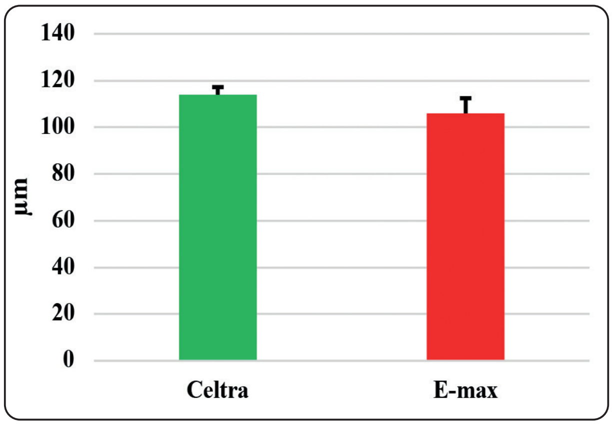

Fig. (7): Bar chart representing comparison of internal adaptation between different materials using deep chamfer technique.

Determining the internal adaptation between different materials using vertical preparation technique

Comparison of internal adaptation between different material using vertical preparation technique showed significant increase of internal adaptation in E-max (133.3±8.2) compared with Celtra (122.1±4.7), p value = 0.028. **Table (6), Figure (8)**

Table (6): Comparison of internal adaptation between different materials using vertical preparation technique.

Vertical preparation		Celtra N=5	E-max N=5	P value
Internal adaptation	Range	(117.9-129)	(122.6-144.8)	0.028*
	Mean ± SD	122.1±4.7	133.3±8.2	

: Significant difference at P value < 0.05

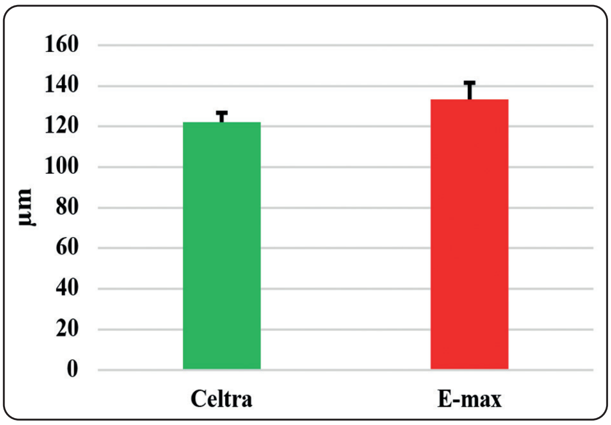

Fig. (8): Bar chart representing comparison of internal adaptation between different materials using vertical preparation technique.

DISCUSSION

Management of the interface between restorative material and cavity is a critical factor in reducing the effect of micro leakage. One of the most significant problems affecting restorative dentistry today is the failure of restorative materials to completely bond to enamel and, even more so, to dentine. The ensuing micro leakage has been shown to result in a variety of sequelae (Taylor 1992) (11) including hypersensitivity of restored teeth, discoloration at the margins of cavities and restorations, recurrent caries, pulp inflammation and failure of endodontic treatment.

The notion of minimally invasive dental restorations is crucial for the efficacy of dental restorations. Thus, minimally thick all-ceramic restorations have been commonly advocated. (12) Technology has contributed significantly to this conservative approach of dentistry (13). Crown margins are critical in influencing the stability of restorations and related supporting tissues throughout time. Consideration must be given to the design and creation of appropriate finishing lines based on the restorative material being used, the desired aesthetic result, occlusal considerations, and the condition of the underlying tooth structure; thus, adequate planning increases the likelihood of a successful outcome. (14) The link between the level of the margin and the gingiva may be the most crucial biological component in preserving the long-term health of neighbouring soft tissues. Featheredge preparations enhance the BOPT approach, which provides an innovative concept based on the discovery that the gingival profile. (15) (16) the type of finish line and the selected material have the most influence the marginal adaption of permanent prosthodontics. This study by Halawani et al. (2017) demonstrates that a strong marginal fit is one of the most crucial technical aspects for the long-term effectiveness of any restoration (17)

This study aims to determine the influence of cervical finish line preparation on the internal adaptation of all ceramic crowns fabricated with CAD/CAM technology (in vitro study). Which is reported an increase in the internal adaptation between vertical preparation (109.9±6.4) and deep chamfer, regardless of the material (109.9±6.4). In addition, regardless of methodology, the difference between E-max (119.6±16) and Celtra (118±5.7). Which concluded that no statistically significant, vertical preparation was an alternative to horizontal preparation and more conservative to sound tooth structure throughout the fabrication of fixed abutments to give a less intrusive option.

Numerous research with differing outcomes has explored the influence of finish-line design on the marginal and internal adaptations of ceramic crowns and diverse results present with chamfer and shoulder finish lines. (18) (19) (20)

The maxillary premolar tooth used in this study mimics the mesiodistal and buccolingual dimensions of real teeth. In addition, the tooth was prepared in line with Ahlers et al (2007) recommendations for all-ceramic restorations. (21) Compared to horizontal preparations, the coronal seal on featheredge preparations is clearly superior. Numerous writers have shown that vertical geometry reduces the distance between the teeth and the crown. It improves the fit, reduces cement exposure, and reduces bacterial penetration. [22] [23] Preparation and restoration design might influence the marginal adaption of the ceramic material used to restore missing tooth structure, which is of highest relevance for the scientific evidence of clinical circumstances. [24] It has been demonstrated that tooth morphology and preparation geometry have an effect on the longevity and dependability of prosthetic restorations. The tooth preparation criteria for crown sample approval were intended to simulate clinical settings.

In these investigations, 500 thermal cycling cycles with hot and cold temperatures were utilised. Each water bath lasted for 25 seconds, followed by a 10-second interval. What was the lowest temperature recorded? (50C). The highest temperature reached 550 degrees Celsius, most likely in an effort to mimic intraoral timings. Although tapered and thin margins have some drawbacks like difficulty in accurate processing and liability to chipping fracture, minimally invasive approaches are indicated to prevent residual dental tissue weakening or pulp insult. As a consequence, reducing coping thickness of restorations and minimal invasive finish lines including Feather-edge are mandatory. [25]

Rego et al standardized natural teeth using high-speed turbine to prepare teeth using a surveyor with mounted rod to achieve a standard taper of 6 and standard height of 4 mm, but it was impossible to standardize the area/volume of obtained specimens. Cortellini et al used abutments fabricated from epoxy resin instead of natural teeth as it is harder to standardize the natural teeth dimensions. [26, 27]

This technique was advocated for measuring internal adaptations of cemented crowns, to permit comparison of different margin designs and to evaluate the fit of restorations. The cross-sectional evaluation of the margins allows greater precision in the determination of measuring points and permits determination of the degree of horizontal discrepancy that is not possible with the direct viewing technique.

The lowest cement thickness values at the occlusal surface were obtained with the deep chamfer finish line configuration, followed by the knife-edge finish line. Cho LR et al., explained that the better adaptation a rounded chamfer finish line preparation was because it allowed the cement to escape more easily. [28]

The cement thickness was maximum with the feather edged preparation, followed by the long deep chamfer design. These margins did not allow the castings to completely seat, because these margins seal earlier and start the filtration process sooner. They substantially decrease the closing angle between the tooth preparation and the restoration and do not allow the cement to escape easily. [29] Deep chamfers and feather edge marginal designs magnify the difference between seating. The degree of lack of seating of crowns influence the widths of the exposed cement lines. The seating and sealing discrepancies are not equal in horizontal designs. Hence, the width of the exposed cement line of a crown cemented on a preparation with a cervical knife-edge is as great as the magnitude of lack of seating of the crown. This was in support of the views given by Grajower R and LewinsteinI. [30]

The same dental technician fabricated all crowns in this study, and tooth preparations and the measurements of marginal fit were performed by the same prosthodontist. Therefore, the data concerning the fit for each marginal design may have been subject to intra-examiner bias. The accuracy in measurements depends on (1) the angle of the surface of the crown margin and (2) the profile readings by the evaluator. Further research will be necessary and should include multiple evaluators to eliminate intra-examiner bias and to increase reliability. A profilometer accurately measures the marginal gap; however, investigators should examine other methods to evaluate marginal accuracy.

CONCLUSIONS

Within the constraints of this study, the following results were concluded that the vertical alignment of finish lines offered an alternative to the horizontal alignment, And no significant difference between E-max and Celtra Due.

Recommendations:

More clinical and biological study is necessary for this work to be scientifically validated and to evaluate the clinical performance (Internal Adaptation) of newly developed CAD/CAM materials such as Celtra Duo produced using CEREC technology, a prospective study will be conducted to determine if clinicians can use the vertical tooth preparation procedure with predictable results.

List of Abbreviations:

CAD- CAM: computer aided design computer aided manufacturing, KE: knife edge, DC: deep chamfer, FPD: fixed-partial-dentures, ZLS: zirconia-reinforced lithium silicate

Declarations:

- Ethics approval and consent to participate

  Not applicable

- Consent for publication

  Not applicable

- Availability of data and materials

  The authors announce that the data supporting the results of this study are existing within the article.

- Competing interests

  No competing interests.

- Funding

  This research did not receive any specific grant from backing supports in the Public, commercial, or not-for-profit sectors.

REFERENCES

1. Fuzzi M, Tricarico M, Cagidiaco E, et al. Nanoleakage and internaladaptation of zirconia and lithium disilicate single crowns withfeather-edge preparation. J Osseointegr. 2017;9:250-262.
2. Rekow E, Silva N, Coelho P, et al. Performance of dental ceramics:challenges for improvements. J Dent Res. 2011;90:937-952.
3. Zarone F, Ferrari M, Mangano F, et al. Digitally oriented materials: focus on lithium disilicate ceramics. Int J Dent. 2016;2016:1-10. https://doi.org/10.1155/2016/9840594.
4. Cortellini D, Canale A. Bonding lithium disilicate ceramic to featheredge tooth preparations: a minimally invasive treatment concept. J Adhes Dent. 2012;14:7-10.
5. Rinke S, Rödiger M, Ziebolz D, Schmidt A. Fabrication of zirconiareinforced lithium silicate ceramic restorations using a complete digital workflow. Case Rep Dent. 2015;2015:1-7. https://doi.org/10. 1155/2015/162178.
6. Barchetta N, Amaral M, Prochnow C, et al. Strength of a zirconiareinforced Lithium silicate ceramic: acid-etching time and resin cement application effects. Int J Periodontics Restorative Dent. 2019; 39:431-437.
7. Imburgia M, Canale A, Cortellini D, Maneschi M, Martucci C, Valenti M. Minimally invasive vertical preparation design for ceramic veneers. Int J Esthet Dent. 2016;11: 460-471.
8. Ozkan Y, Aslan Y. Anterior esthetic restorations using minimally invasive techniques. J Dent Oral Biol. 2017;2:1074.
9. Edelhoff D, Brix O. All-ceramic restorations in different indications: a case series. J Am Dent Assoc. 2011;142:14-19.
10. Paniz G, Nart J, Gobbato L, et al. Clinical periodontal response to anterior all-ceramic crowns with either chamfer or feather-edge subgingival tooth preparations: six-month results and patient perception. Int J Periodontics Restorative Dent. 2017;37:61-68.
11. Taylor MJ, Lynch E. Microleakage. J Dent 1992; 20: 3-10.
12. Imburgia M, Canale A, Cortellini D, Maneschi M, Martucci C, Valenti M. Minimally invasive vertical preparation design for ceramic veneers. Int J Esthet Dent. 2016;11:460-471
13. Aldafeeri, H. R., Al-Zordk, W. A., & Ghazy, M. H. (2019). Marginal Accuracy of Machinable Monolithic Zirconia Laminate Veneers. Journal of Dental and Medical Sciences. Volume 18, P 67-74.

14. Philip Newsome and Siobhan Owen, Improving your margins (Clinical), International Dentistry SA VOL. 11, NO. 6).
15. ACSBNT L. (SBEVBUF periodontal and prosthetic lectures. Boston University 4DIPPM PG (SBEVBUF %FOU-JTUSZ, 1971. Boston: Boston Univer- sity Press, 1971.
16. Kay HB. Criteria for restora- tive contours in the altered periodontal environment. Int J Periodont Rest Dent 1985; 5:42–63.
17. Halawani, S. M., & Al-Harbi, S. A. (2017). Marginal adaptation of fixed prosthodontics. International Journal of Medicine in Developing Countries, 1(2), 78-84.
18. Yu H, Chen YH, Cheng H, Sawase T. Finish-line designs for ceramic crowns: A systematic review and meta-analysis. J Prosthet Dent 2019;122:22–30.e5.
19. Awad D, Stawarczyk B, Liebermann A, Ilie N. Translucency of esthetic dental restorative CAD/CAM materials and composite resins with respect to thickness and surface roughness. J Prosthet Dent 2015; 113:534–540.
20. Euán R, Figueras-Álvarez O, Cabratosa-Termes J, Brufau-de Barberà M, Gomes-Azevedo S. Comparison of the marginal adaptation of zirconium dioxide crowns in preparations with two different finish lines. J Prosthodont 2012;21:291–5.
21. Frankenberger, R., Mörig, G., Blunck, U., Hajtó, J., Pröbster, L., & Ahlers, M. O. (2007). Guidelines on the preparation for all-ceramic inlays and partial crowns—with special regard to CAD/CAM-technology. Teamwork, 10, 86-92.
22. Rosner D. Function, placement,and reproduction of bevels for gold castings. J Prosthet Dent 1963;13:1160– 1166.
23. Cagidiaco MC, Ferrari M, Bertelli. Cement thickness and microleakage under metal-ceramic restorations with a facial butted margin: an in vivo investigation.
24. Tamimi, S., Essam, E., & El Guindy, J. (2017). Effect of Different Preparation Designs on the Fracture Load of Two Machinable Laminate Veneers. Al-Azhar Dental Journal for Girls, 4(1), 63-70.
25. Schmitz JH, Beani M. Effect of different cement types on monolithic lithium disilicate complete crowns with feather-edge preparation design in the posterior region. J Prosthet Dent. 2016;115:678-683.
26. Rego M, Santiago L. Retention of provisional crowns cemented with eight temporary cements: comparative study. J Appl Oral Sci. 2004; 12:209-212.
27. Cortellini D, Canale A, Souza R, et al. Durability and Weibull characteristics of lithium disilicate crowns bonded on abutments with knifeedge and large chamfer finish lines after cyclic loading. J Prosthodont. 2015;24:615-619.
28. Cho LR, Choi JM, Yi YJ, Park CJ. Effect of finish line-variants on marginal accuracy [13] and Fracture strength of ceramic optimized polymer /fiber-reinforced composite crowns. J Prosthet Dent.2004;91:554-59.
29. Tjan AHL, Sarkissian R, Miller GD. Effect of multiple axialgrooves on the marginal [8] adaptation of full cast-gold crowns. J Prosthet Dent. 1981;46:399-403.
30. Grajower R, Lewinstein I. A mathematical treatise on the Fit of crown castings. [14] J Prosthet Dent. 1983;49:663-74.