AL-AZHAR
Assiut Dental Journal

The Official Publication of The Faculty of Dental Medicine, Al-Azhar Assiut University, Egypt

AADJ, Vol. 2, No. 1, APRIL (2019) — PP. 11:19

ISSN 2682-2822

Marginal Accuracy of Fully Contoured Zirconia Veneer With Two Preparation Designs

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Codex : 02/1901

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ABSTRACT

Aim: The purpose of this study is to evaluate the marginal accuracy of fully contoured zirconia laminate veneer utilizing two preparation designs; butt joint incisal reduction and incisal chamfer with palatal over lab. ***Subjects and Methods***: forty-eight maxillary central incisors were prepared into two designs in relation to incisal finish line of laminate preparation; butt joint incisal reduction and incisal chamfer with palatal over lab. Half of samples were restored with pressable lithium disilicate (e.max) as control group, and the other half were restored with fully contoured translucent machinable zirconia (Bruxzair). All laminates were cemented with resin cement and the marginal accuracy were measured. ***Results:*** With butt-joint margin design; it was found that e.max group recorded statistically significant higher marginal gap mean value (63.54±1.8 μm) than translucent Zirconia group (57.19±8.4 μm) as indicated by unpaired t-test (t value=2.6, P=0.0179<0.05) .With over-lap margin design; it was found that e.max group recorded statistically significant higher marginal gap mean value (73.46±11.2 μm) than translucent Zirconia group (64.58±5.1 μm) as indicated by unpaired t-test (t value=2.5, P=0.0203 < 0.05). ***Conclusion:*** The marginal accuracy of the fully contoured zirconia veneer showed high adaptation supporting its usage for laminate veneer fabrication.

KEYWORDS

Laminate , Veneer, Marginal, Zirconia, Fabrication

INTRODUCTION

Laminate veneer is considered as one of the breaking through modalities utilized for esthetic rehabilitation of smile zone in addition to the benefit of being conservative,(1-4) this was accompanied with improvements in ceramic bonding procedures.(5) Within the last decade laminate veneer became a routine treatment performed in dental clinics, originally feldspathic porcelain was the first to be used in construction of such restoration.(6,7) Meanwhile and after introduction of lithium disilicate, this material attained great predominance for construction of laminate veneer.(8,9) Although zirconia as a high strength restorative material was popular but it was not used in construction of laminates because of esthetic issues and bonding restrictions.(10-14) Recently with the modification of zirconia structure,

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high esthetic fully contoured zirconia was proposed for construction of laminate veneer. From the other side, advances in bonding of zirconia has led to spread of zirconia in construction and application in conservative and adhesive restorations. [15-22]

While material selection based on strength and optical properties for prosthetic fabrication is considered one of the most important interest in research, also marginal accuracy investigation is considered fundamental point to search about.[23-25] Marginal accuracy is a very demanding perquisite when fabricating a laminate.[26] An inadequate fit creates a potential space between the restoration and the prepared tooth. As this space increase, more luting material is exposed to the oral environment. Because resin cementation suffers from polymerization shrinkage and wear such increased gap will absorb water leading to resin deterioration.[27-31] Subsequently bacterial plaque can easily accumulate in this defective area, which in turn can result in gingival inflammation and increase risk of caries invasion.[32,33] From the other side, variation in the fit can create stress concentrations which may reduce the strength of restoration and consequently cause its fracture.[34,35] McLean proposed that restoration would be successful if marginal gaps and cement thickness of less than 120 μm could be achieved[36] ,this was consistent with other reports.[37,38] The preparation design for incisal edge were assumed to have reflection on the marginal adaptation of the veneer. There was predominance of incisal overlap preparation within clinical situations.[39-41] The overlap preparations include two incisal design proposed by the literature, the butt-joint and the palatal over-lap preparation.[42,42] The purpose of this study is to evaluate the marginal adaptation of fully contoured anterior zirconia veneers using two types of incisal preparation designs. The null hypothesis is that machined fully contoured zirconia veneer will not reveal high marginal adaptation as pressable lithium disilicate veneer.

MATERIAL AND METHOD

Samples preparation: Freshly extracted, forty-eight of the maxillary central incisors were collected with average anatomic crown length of (10 mm), homogenous and faciopalatal dimension. Each tooth was mounted individually in rings made by putty silicon and filled with an epoxy resin (Ebalta) uncovering 2mm below the cementoenamel junction. Before preparation, we take putty index for each tooth using condensation silicone (polysiloxane) impression material (Zetaplus, Zhermack) to obtain pre-preparation index. This index is used for justification of preparation uniformity and standardization.

Samples grouping: Teeth was randomly assigned to two groups according to laminate veneer ceramic material & fabrication technique, each group includes twenty four specimens (N=24): **Group I:** (Control Group) Laminate veneers were constructed with heat pressed lithium disilicate glass ceramic(e.max) **Group II:** (test group) Laminate veneers were constructed with machine milled fully contoured translucent zirconia (Bruxzair). Each group was divided in to two sub-groups according to incisal edge preparation design **Sub group A.** laminate veneer with Butt-joint incisal reduction. **Sub group B.** laminate veneers with incisal chamfer overlap reduction.

Teeth preparation: Teeth were prepared using rotary instrument under water coolant. Traditional veneer preparation were done with assistance of self-limiting three depth cutting wheel (834-314-021-LVS1- Brasseler Komet Germany) and putty index for standardization of preparations to obtain: incisal reduction;1.5 mm, Facial reduction with cervical **finish line:** 0.5 mm in the cervical third and 0.7mm in the middle and incisal third. Cervical finish lines were developed 1 mm above the cementoenamel junction, so the finish lines of the tooth preparations were located entirely on enamel. Tapered diamond bur with round tip of 0.5mm in diameter (6844-314-016-LVS3 Komet Germany) used to prepare and refine the facial surface of the teeth with cervical finish line till the depth grooves disappears. **Finial incisal preparation:** preparation of incisal over lab for subgroup(B), this is performed for half of the samples (1mm in depth from incisal edge and 0.5 thickness). Finally finishing and smoothening of preparation using fine grit diamond stone.

Impressions making and master die fabrication for control group (I) Lithium disilicate: One-step, double-mix Impressions for prepared teeth were made with addition type silicone (poly vinyl siloxane) impression material (3M ESPE) a .Impressions were poured with a stone of high hardness and low expansion type IV (BEGO stone). The stone powder was mixed with distilled water according to manufacturer instruction water-powder ratio using vacuum mixer (Easy mix BEGO).

Ceramic veneer fabrication, lithium disilicate (E.max): a total number of 24 veneers in the control group were waxed to a uniform thickness of 0.5mm at cervical third and 0.7mm at the middle and incisal thirds. The thickness of veneer checked by the index and by wax caliper. Each four veneers were sprued with 3mm diameter sprue at the same time and arranged in a turbine shaped pattern, and the attachment points was rounded and smoothed.

Investing was carried out with Ivoclar-vivadent IPS press VEST speed investment material. The e-max ingots of LT A2 shade were used for fabrication of veneer with EP 3000 Ivoclar pressing furnace, procedures were performed with E.max materials and protocol (Ivoclar-vivadent). The veneers were separated from the sprues by a diamond disk and finished. Dimensions of pressed veneers were checked using the putty index & caliper for 0.5mm and 0.7mm thicknesses at cervical third and incisal two thirds respectively and 10mm in length. All veneers were glazed using Ivoclar vivadent e.max ceram Universal Glaze.

Fabrication of fully contoured zirconia (Bruxzair): Extra oral scanner (Identica blue) was used for scanning of the teeth and the restorations were designed using Exocad software. The restorations designs were adjusted for all of the zirconia veneers to obtain veneers of 10 mm length, 0.7mm thickness at middle third and 0.5 mm at cervical third. Parameter adjustment to 0.08mm for cement space, then STL file of designed restoration was transferred to dental CAM software. Bruxzir pre-shaded blank (A2 shade 200) was inserted into the milling machine (VHF CAM5-S1) five axis milling machine. Enlargement factor of the zirconia blank was obtained from the label on the blank and inserted into the dental CAM software. Individual designs of the scanned dies were arranged in the blank then mill process was accomplished. All milled specimens were separated from the blank by cutting the sprues, and then ultrasonic cleaning in solution of 99% Isopropanol for 30 seconds. Before sintering, all milled specimens dried for 2min under a special drying lamp (Bredent). Sintering were done using (Nabertherm) sintering furnace for 9 hours at Temperature 1560 c. Finally, all milled specimens glazed by E-Max ceram glaze.

Cementation of samples, before cementation conditioning of restorations and teeth were performed as follows :(A) Conditioning of the E-max ceramic surface: The internal surface of the ceramic veneers was etched with 9% hydrofluoric acid etching gel (Ultradent, USA) for 30 seconds and rinsed with water and followed by drying. The internal surface of the veneers were coated with single bond universal (3M ESPE)) for 20 seconds followed by gentle air drying for 5 second.(B) Conditioning of Translucent zirconia by sandblasting using AL_2O for 20 second then ultrasonic cleaning followed by application of single bond universal and gentle air drying for 5 seconds.(C) Conditioning of the teeth surfaces were done by etching with 37.5%phosphoric acid for 30 seconds and rinsed with water for 30 seconds and drying. Followed by application of a thin coat of single bond universal for 20 seconds and gentle air thinning for 5 seconds.

Translucent Dual-curing RelyX Ultimate luting resin cement (3M, ESPE, clicker, RelyX, Deutschland GmbH) Was used to bond the ceramic veneers to prepared teeth. The ceramic veneers were seated on the prepared teeth with light pressure. Initial photopolymerization for 5 seconds then gross excess cement was removed with an explorer in cutting motion, parallel to the margin. Final photopolymerization was performed for 20 seconds for facial and palatal margins of each ceramic veneer. Scalpel was used to remove excess of cement remained then rubber polishing.

Evaluation of Marginal Gap: Measurements were conducted by using USB digital microscope (Scope Capture Digital Microscope, Guangdong, China). Shots of margins were taken for each tooth using digital camera fitted on the microscope used fixed magnification of 40 X. Four reference points were marked on each tooth –restoration interface using indelible marker. These points were cervical, palatal, mesial and distal. Then morphometric measurement was done on IBM compatible personal computer. The software (Scope Capture 1.1.1.1. Ltd Co.) which was used for image analysis was calibrated, the gap distance was measured for each shot. The data obtained were collected, tabulated and subjected to statistical analysis.

RESULTS

The Marginal gap was measured for the forty-eight central incisor at four reference points cervical, palatal, mesial and distal and then average of the marginal gap over the four sites were calculated for each tooth. Descriptive statistics of marginal gap (μm) showing mean, standard deviation (SD), minimum, maximum and 95% confidence intervals (low and high) values for both ceramic groups with both margin design are summarized in table (1) and table (2).

According to the ceramic type, With butt-joint margin design; it was found that e.max group recorded statistically significant higher marginal gap mean value (63.54±1.8 μm) than translucent Zirconia group (57.19±8.4 μm) as indicated by unpaired t-test (t value=2.6, P=0.0179 < 0.05) .With over-lap margin design; it was found that e.max group recorded statistically significant higher marginal gap mean value (73.46±11.2 μm) than translucent Zirconia group (64.58±5.1 μm) as indicated by unpaired t-test (t value=2.5, P=0.0203 < 0.05) as shown in table (1).

From the other side butt-joint versus Over-lap margin design, Translucent Zirconia group; it was found that over-lap subgroup recorded statistically significant higher marginal gap mean value (64.58±5.1 μm) than butt-joint subgroup (57.19±8.4 μm) as indicated by paired t-test (t value=6.9, P=<0.0001 < 0.05). E.max group; it was found that over-lap subgroup recorded statistically significant higher marginal gap mean value (73.46±11.2 μm) than butt-joint subgroup (63.54±1.8 μm) as indicated by paired t-test (t value=3.2, P=0.008 < 0.05) as shown in table (2)

Table (1) *Mean values and standard deviation of marginal gap in relation to both ceramic type*

Variables		Margin design		Statistics
		Butt-joint	Over-lap	P value
Ceramic type	Translucent Zirconia	57.19±8.4	64.58±5.1	<0.0001*
	e.max	63.54±1.8	73.46±11.2	0.008*
Statistics	P value	0.0179*	0.0203*	

*; *significant (p < 0.05)*

ns; non-significant (p>0.05)

Table (2) *Mean values and standard deviation of marginal gap for both ceramic groups as function of margin design*

Variables		Mean± SD	Min.	Max.	95% CI	
					Low	High
Butt-joint	Translucent Zirconia	57.19±8.4	47.33	68.33	51.87	62.52
	e.max	63.54±1.8	60.67	67.67	62.36	64.73
Over-lap	Translucent Zirconia	64.58±5.1	57.67	72	61.35	67.82
	e.max	73.46±11.2	61	88.33	66.35	80.33

In general, the effect of ceramic type regardless to margin design totally, there was significant difference between both ceramic groups as indicated by two-way ANOVA test ($F=12.36$, $p=0.001 < 0.05$) where E.max recorded higher values than Translucent Zirconia. In relation to the effect of margin design irrespective of ceramic type, the margin design totally reflected on marginal gap results significantly as indicated by two-way ANOVA test ($F=15.98$, $p=0.0002 < 0.05$) where over-lap margin recorded higher values than butt-joint.

DISCUSSION

The margins of prosthetic restorations has great infulence on the surviaval rate as it lead to intimate seal between different interfaces. This was prononced with the recent trend to ward conservative approch, laminate veneer as aconservative and esthtitical modality dectate the maximal marginal adaptation to fullfill the goal of treatment in addition to long term performance.(23-26) Accordingly cement exposure in that stage means deterioration of assembly and discoloration leading to rapid failure.(27-31) A lthough the venner application is a common treatment now adays but with continous modifacation of production techniques & ceramic materials this give rise to a lot of treatment modalities for veneer fabrication. Veneer could be fabrocated by traditional hand layering on refractory die , presssing inside investment mold & digital machininig from blocks with CAD/CAM systems. From the material point of veiw ,veneer could be fabricated from feldspathic,(6,7) lucite ceramics,(44) lithium silicate,(45) lithuim disilicate,(8,9) and zerconia.(10-22) The most common among the previous modalites is pressable lithuim disilcate as economic and esthetic in addition to durable functional performance, from the other side milling offeres easy, fast and consistant when compared to press fbrication. Milled glass ceramics is expensive so searching for economic material that fullfill esthetic and functional requirments to be used incompination with milling technology was the target. Structural modification of zirconia was in progress till elaporation of transulucent zirconia which fulfilled the previous target. Before that, utilization of zerconia in veneer fabrication was not implimented as the original zerconia is completely opaque.(46) Evaluation of fully controured cubic zerconia transuluncy,zrconia showed higher transulcensy values than lithum disilicate (47)From the other side the high mechanical properties of zerconia give rise to high fracture resistance of venner restoration coupled with advances in bonding procedure.(48)

In the present study the machined fully contoured transulucent zerconia is the point of intrest and compared to pressed lithuim disilicate(control group) as the common traditional alternative for veneer fabrication. Clinical reviews showed that chairside CAD/CAM ceramic laminate venners have high survival rates in addition to be clinicaly succefull.(49) Litrature with in invitro studies have been investigating such recent improvements within the marginal profile of veneers. For while there was some reports supports the press technology as an accurate and superior production of margins, ABOSHLAB etal founds that pressable lithuim disilicate was superior to machinable leucite containing blocks milled by cerec inlab mcxl.(23) Also pressing of vita vm9 resulted in superior margianal adaptaion than machinable vitamark II milled by ceramill motion II**.** In contrary, It was found that material selection added impact to marginal accuracy even when same milling machine used.(50) Further interpretations of the previous results should be submitted cosidering the material selection in addition to the method of fabrication at the same time. So the results of press superiority was due to compairing press of lithium disilicate with weak machinable materilas other than zerconia and the using of 4 axis milling machine.(47,48) Milling performance was adequate when the comparison of machinable lithum disilcate crowns millied by 4 axis milling machine(cerec inlab mcxl) and pressable lithuim disilicate as it revealed non signficant difference between the two methods of fabrication.(51) Other study showed inhanced adaptation with milling in relation to pressing.(52) Regarding milling machine variation Hamza etal found that there is significant reflection on marginal accuracy could rise from the use 4 axis or 5 axis milling machine as the later produced superior results.(53)

The over all results of the marginal gap of the both group was in a range below 100 microns which is considered as a common range reported in a lot of scientific reports.[36-38] Obiviously the e.max specimens showed significant higher marginal gap values compared to milled transulecent zerconia (Bruxzair). The results of high marginal fit for zerconia veneer was due to both the method of construction and materail properties at the same time, five axis machine and zerconia restoration with high mechanical properties. The five axis machine enable more detaile production,[53]partial densification impart zerconia resistant to fracure&chipping during milling[46] weaker and brittle ceramics suffer from marginal chipping during milling rsulting in inaccuracies specially in thin margins as vibrations of the milling tools are the causative of such defect.[46] On the contrary, the traditional pressing technique is dependent on the lost wax technique, the final restoration was obtained after investing of wax pattern which is hand made procedure not cosistant as in CAD/CAM platform. In addition to that wax distortion results from high coefficent of thermal expansion and shrikage in the range of 0.4% during carving & addtion plus 0.2% within burnout process.[24,25,38]

From the prespctive of margin design. Over lap design for veneer preparation has been proposed for better transulucency and esthtetic outcome as it mask the incisal finish line interface more than non overlap design also provision of positive seat for ceramic veneer.[54]Two incisal overlap designs were utilized; the butt joint and the palatal over lab.[42,43] The palatal over lab showed significant higher values compared to butt joint design which was in agrement with previous studies.[55] This was attributed to complixety of preparation of the palatal over lab in relation to the butt joint design with subsequent limitation of path of insertion in addition of high risk of fracture and chipping in addition to impression detail and finish line demarcation on the working model is more easier in butt joint preparation.[56,57]

The null hypothesis that machined fully contoured zirconia veneer will not reveal high marginal adaptation as pressable lithium disilicate veneer was rejected.

CONCLUSION

Within the limitation of this study, fully contoyred zerconia veneer milled with five axis milling machine revealed high marginal accuracy that surpassing pressed glass ceramic. From the other side butt joint preperation showed privilage in accuray in relation to palatal over lab design.

RECOMMENDATION

Fully contoured zirconia attained high performance when used for fabrication of lainate veneer rendering such application as one of the premium choieces for clinical esthetic rehablitation.

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AADJ, Vol. 2, No. 1, April (2019) — PP. 19

الملخص العربي

الدقة الحافية لقشرة الزيركونيا الكلية مع التحضير باستخدام اثنان من التصاميم

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الأهداف

لا تعتبر الزيركونيا الكلية استخداما معتادا لتصنيع القشرة السطحية. الهدف من هذه الدراسة هو تقييم الدقة الحافيية للقشرة السطحية المصنعة من الزيركونيا الكلية مع استخدام اثنان من التصاميم: السطح القاطعي مستوي والسطح القاطعي مع تداخل حنكي .

الأساليب والمواد

تم تحضير ثمانية وأربعون من القواطع الأمامية الرئيسية إلى اثنان من التصاميم طبقا لخط النهاية علي السطح القاطعي عند تحضير القشرة السطحية: السطح القاطعي مستوي و السطح القاطعي مع تداخل حنكي. نصف العينات تم تعويضها باستخدام الليثيوم ثنائي السيليكات المضغوط (أي ماكس) والنصف الآخر تم تعويضها باستخدام الزيركونيا الكلية ذات الشفافية المخروطة (بروكزير). تم لصق كل العينات باستخدام اللصق الراتنجي وبعد ذلك تم قياس الدقة الحافية.

النتائج

في حالة العينات مع تصميم السطح القاطعي مستوي وجد أن عينات (أي ماكس) سجلت قيم للفجوة الحافية اعلي مع تباين احصائي مؤكد أكثر من عينات(بروكزير) وفي حالة العينات مع تصميم السطح القاطعي مع تداخل حنكي وجد أيضا ان عينات (أي ماكس) سجلت قيم للفجوة الحافية اعلي مع تباين أحصائي مؤكد أكثر من عينات(بروكزير).

الاستنتاج

أظهرت الدقة الحافية لقشرة الزيركونيا الكلية تطابق حافي عالي الدقة مما يدعم استخدامها في تصنيع القشرة السطحية.