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EFFECT OF TWO PREPARATION DESIGNS AND METHODS OF CONSTRUCTION ON THE FRACTURE RESISTANCE OF GLASS CERAMICS LAMINATE VENEERS

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ABSTRACT

Purpose: To evaluate the effect of marginal finish line design and fabrication techniques on the fracture resistance of lithium disilicate laminate veneer. **Materials and methods**: A total of 24 veneers were designed, constructed, and divided into two main groups according to preparation design Chamfer 0.3 mm finish line (n=12) and, Chisel finish line (n=12). Each group was then divided into two subgroups according to the technique of veneer construction, veneers constructed by (CAD/CAM system) out of e max CAD blocks (n=6), and veneers constructed by (press on technology) using e max press ingots (n=6). then the veneers bonded to corresponding epoxy resin dies using resin cement. Finally fracture resistance test was done for all specimens using universal testing machine. **Results:** The highest fracture resistance values were recorded in the group of chisel marginal design fabricated by CAD/CAM technique. The lowest fracture resistance values were recorded in the group of 0.3mm chamfer margin design fabricated by Press technique. Regardless to margin design there was a significant difference between both processing techniques as indicated by two-way ANOVA test ($p=0.0178<0.05$) where (CAD/CAM >Press). Irrespective of material type it was found that margin design significantly influenced mean as indicated by two-way ANOVA test ($p=0.0001<0.05$) where (Chisel ≥ Chamfer). It was found that the Chisel margin design recorded statistically non-significant values between CAD/CAM group (302.64±46.91N) and Press group (297.37±56.5N) as indicated by unpaired t-test ($P=0.8892>0.05$). It was found that the Chamfer margin design recorded statistically significant higher fracture resistance mean value with CAD/CAM group (245.85±56.37N) than Press group (129.71±19.49 N) as indicated by unpaired t-test ($P=0.002<0.05$) **Conclusions:** The technique of fabrication of ceramic laminate veneer restorations has a crucial effect on its performance with the regard to fracture resistance. IPS e.max CAD could be considered as a valid restoration than IPS e.max press.

INTRODUCTION

The development of dental ceramics offers clinicians many options for creating highly esthetic and functional ceramic veneers. Evolution of ceramic materials and adhesive systems permits improvement of the beauty of smile and the self-esteem of the patient. Clinicians should understand the latest restorative materials in order to be able to recommend them and their applications and techniques, and to ensure success of the clinical case [1-3].

The introduction of the porcelain veneer afforded many advantages and solutions for the dentists and patients as well because its good esthetics, durability, strength, save the periodontium, and color stability. Lithium disilicate ceramics frequently used for laminate veneers fabrication because they have the advantages of long term clinical acceptability, good bonding characteristics, favorable esthetics and lake for porcelain veneering need. Also, lithium disilicate can be fabricated either by Press technique or through CAD/CAM technology [4-6].

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A cyclical evolution has undergone on the preparation for porcelain veneers. It started in the early 1980s with minimal or no preparation, then to more aggressive tooth reduction in the 1990s, and then came back to very little as possible [7,8].

The superior mechanical properties and fabrication techniques of lithium disilicate allow clinicians to reconsider the established preparation guidelines, such as; Reducing finish line preparations thickness from 0.5 to 0.3 mm and Changing finish line configuration from chamfer to minimally invasive knife edge margins[9].

Vertical preparations have been appeared again with lithium disilicate veneers in some recent studies. Where a higher failure load was measured for cemented lithium disilicate veneers with knife-edge margins versus chamfer. In addition; marginal opening with the feather-edge finish line was significantly lower than that of the chamfer, shoulder and mini-chamfer finish line types [10-12].

One of the most important mechanical property of ceramic restorations is strength. Because of the high rate of failure new all-ceramic restorations were developed. So, evaluation of fracture resistance is important [13-16]. The hypothesis of this study was that preparation design and fabrication technique influences the fracture resistance of lithium disilicate laminate veneers.

MATERIALS & METHODS:

Two symmetrical upper left central incisors were carefully selected and centralized with a paralometer device (Paraflex, Bego, Bremer, Germany) in acrylic block (Acrostone, Cairo, Egypt) using a special mold, then prepared using computer numerical controlled (3 axis cencroid CNC machine, USA) to obtain the two master dies.

Each master die duplicated to twelve epoxy resin dies (Chemapoxy 150 A and B resin, CMB Chemicals, Egypt) by taking multiple impressions with monophasic regular body addition silicone material (Zhermack, Rovigo, Italy) using specially fabricated tray.

Fabrication of standard CAD/CAM wax pattern:

For the purpose of standardization of CAD/CAM and pressable veneers in term of shape and thickness, the procedure was performed in two main steps:

1. Fabrication of standard CAD/CAM wax pattern
2. Using of standard wax pattern for production of CAD/CAM and pressable veneers.

Two epoxy dies one for chamfer preparation design and the other for chisel one was scanned and wax pattern for each was designed and milled as follow:

The epoxy resin dies were sprayed by shera scanspray (Shera werkstoff-technologie, Germany) and fixed in the ceramill transfer kit (Amann Girrbach Vorarlberg, Austria) with clay (Patamode sarl, croudon, USA). Then inserted in ceramill map 400 scanner (Amann Girrbach Vorarlberg, Austria) to be ready for scanning. the restorations parameters were inserted to determine the restoration thickness at cervical middle, and incisal thirds to be (0.3 mm, 0.5 mm and 0.7 mm) for 0.3 chamfer margin design and (0.2 mm, 0.4 mm and 0.6 mm) for chisel margin design.

The ceramill motion 2 (Amann Girrbach Vorarlberg, Austria) milling machine was then activated and the (***on dent***) wax blank (On dent-WAX-ON DISC WHITE, TURKEY) was fixed in the spindle of the milling machine and the door was closed then the milling icon was clicked to start the milling process.

A drop of glycerin as a viscous material was painted on the fitting surface of the milled wax pattern then, it was seated on its corresponding epoxy die as shown in **(Fig 1)**.

Fabrication of CAD/CAM samples

The two models obtained from the scanned wax patterns were matched with the corresponding scanned epoxy dies to design the CAD/CAM veneers and wax pattern used for pressable veneer fabrication.

Shera scanspray was applied to the outer surface of wax pattern, fitted in transfer kit by clay, and scanned using ceramill map 400 scanner and ceramill mid software. IPS e.max CAD blocks were used for milling of twelve veneers, six for each preparation design. And wax blank was used for milling of twelve wax patterns for pressable veneers fabrication six for each preparation design

IPS e-max CAD ceramic veneers were crystallized and glazed in ceramic furnace (Programat P310, Ivoclar Vivadent AG, Schaan/Liechtenstein) by selection of crystallization and glaze firing cycle. Then the obtained e.max CAD veneers were verified on the corresponding epoxy resin dies to be ready for cementation. **(Fig 2)**

Fabrication of pressable samples

The obtained milled wax patterns fit were verified on their corresponding epoxy dies. Then used to fabricate e.max press samples according manufacture instructions as follow:

Each wax pattern was attached to the pressing ring using wax (Cerita 996C, Asia Pacific) sprue 5 mm length and 3 mm gauge at the incisal edge. Freshly vacuum mixed investment material (Dentaurum, Pforzheim, Germany Powder: 059530Liquid: 079411) was poured on a vibrator table. After chemical setting of the investment (45 min

The preheated investment cylinder along with the ceramic ingot were placed at the center of special press furnace (IPS Empress EP 3010 hot press furnace, Ivoclar-Vivadent AG, Schaan, FL). After manual closing of the furnace head, the program was activated, and the press process ran automatically. The pressing procedure was done according to manufacture instructions. An acoustic indicated the end of the pressing cycle.

After approximately 1 hour, the investment cylinder was removed from the press furnace. The investment cylinder was separated, using a separating disc to create a predetermined break point. The rough investment was removed with glass blasting pearls at 2 bar pressure. The pressed restorations were removed and cut from the sprues and the attachment points were removed with appropriate bur.

The application of glazing procedure took place in Programat P100 with Empress Glasur D64847 (Ivoclar-Vivadent AG, Schaan, FL) according to manufacturing instructions. The press ceramic laminate veneers fit was verified on the corresponding epoxy resin dies.

Cementation procedure:

The veneer and epoxy dies were carefully cleaned in an ultrasonic cleaner with distilled water for 10 minutes to remove any residual contaminants and then was left to dry.

Hydrofluoric acid gel (DentoBond Porcelain Etch, ITENA, France) (9% concentration) was applied to the inner surfaces of the veneer for 20 seconds according to manufacture recommendations, while the outer surface was protected with putty silicone material. An acid residue was removed by air water spray for 60 seconds and then dried for 20 seconds with compressed air until the internal surface of the restoration has showed frosted white appearance.

Silane coupling agent (DentoBond Porcelain silane, ITENA, France) was then applied to the etched inner surfaces of the veneer structure and allowed to dry for 60 seconds according to manufacture instructions.

A thin coat of dual cure self-adhesive resin cement (Totalcem resin cement, ITENA, France) was applied to the inner surface of the veneers and then seated on its corresponding epoxy die under static load 1Kg for 20 seconds[17,18]using cementing device specially fabricated for this study.

Excess cement was removed immediately with an explorer then visible light curing unit (3M ESPE Dental products, St Paul, USA) was used and curing was carried out for 20 seconds from the incisal, gingival, mesial, and distal direction each respectively.

All samples were individually mounted on a computer-controlled material testing machine (Model 3345; Instron Industrial Products, Norwood, MA, USA) with a loadcell of 5 kN and data were recorded using computer software (Instron® Bluehill Lite Software). Samples were secured to the lower fixed compartment of testing machine by tightening screws. Fracture test was done by compressive mode of load using a metallic rod with round tip applied incisally at 135^o angle (through fixing the sample in specially designed 45^o angle jig) attached to the upper movable compartment of testing machine traveling at cross-head speed of 1mm/min. with tin foil sheet in-between to achieve homogenous stress distribution and minimization of the transmission of local force peaks. The load at failure manifested by an audible crack and confirmed by a sharp drop at load-deflection curve recorded using computer software (Bluehill Lite Software Instron® Instruments). The load required to fracture was recorded in Newton.

All cemented laminate veneers were subjected to load until fracture as mentioned before. The final data obtained were collected, tabulated and then subjected to statistical analysis.

RESULTS

The results were analyzed using Graph Pad Instat (Graph Pad, Inc.) software for windows. A value of $P \leq 0.05$ was considered statistically significant. Continuous variables were expressed as the mean and standard deviation. After homogeneity of variance and normal distribution of errors had been confirmed, a two -way analysis of variance was performed to detect effect of each variable. Student t-test was done for compared pairs. Sample size (n=6) was large enough to detect large effect sizes for main effects and pair-wise comparisons, with the satisfactory level of power set at 80% and a 95% confidence level.

The highest fracture resistance values were recorded in the group of chisel marginal design fabricated by CAD/CAM technique. The lowest fracture resistance values were recorded in the group of 0.3mm chamfer margin design fabricated by Press technique. Regardless to margin design there was a significant difference between both processing techniques as indicated by two-way ANOVA test ($p=0.0178<0.05$) where (CAD/CAM >Press). Irrespective of material type it was found that margin

Table 1: Descriptive statistics of fracture resistance results (Mean values ± SDs) for both processing groups as function of margin type.

Variables		*Mean± SD*	*Min.*	*Max.*	*95% CI*		*Statistics*
				Low	*High*	*P value*	
PRESS	***Chisel***	297.37±56.5	227.72	410.12	230.6	364.2	0.0012*
	Chamfer	129.71±19.49	86	159.18	105.8	153.7	
CAD CAM	***Chisel***	302.64±46.91	184.76	396.12	241.3	363.9	0.2121 ***ns***
	Chamfer	245.85±56.37	117.72	338.6	176.4	315.3	

**; significant (p<0.05) ns; non-significant (p>0.05)*

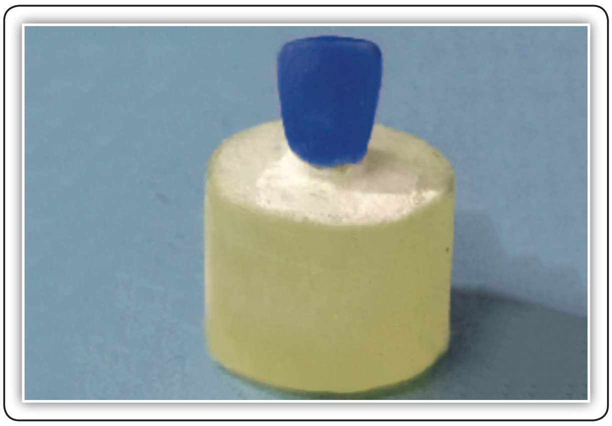

Fig. (1) Standard CAD/CAM wax pattern

Fig. (2) E.max CAD veneer fitted on corresponding epoxy die

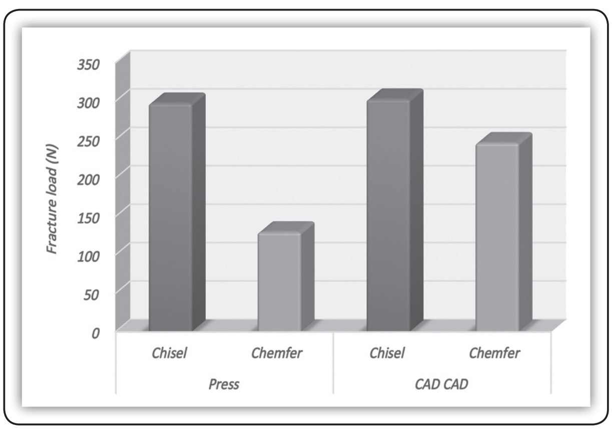

Fig (3) Column chart of fracture resistance mean values for both processing groups with different margin type.

design significantly influenced mean as indicated by two-way ANOVA test ($p=0.0001<0.05$) where (Chisel ≥ Chamfer). It was found that the Chisel margin design recorded statistically non-significant values between CAD/CAM group (302.64±46.91N) and Press group (297.37±56.5N) as indicated by unpaired t-test ($P=0.8892>0.05$). It was found that the Chamfer margin design recorded statistically significant higher fracture resistance mean value with CAD/CAM group (245.85±56.37N) than Press group (129.71±19.49 N) as indicated by unpaired t-test ($P=0.002<0.05$). the data were summarized in (**table 1**) and graphically drawn in (**figure 3**).

DISCUSSION

Preservation of tooth structure is a major driving force in restorative dentistry. From a biomimetic perspective, the conservation of tooth structure is paramount in maintaining the suitable equilibrium between biological, mechanical, functional, and esthetic parameters [1,7].

The development of dental ceramics offers clinicians many options for creating highly esthetic and functional ceramic veneers. Strength of ceramic veneers is a multifactorial property, governed by the thickness of selected ceramic material as well as the configuration of the constructed laminate veneer [2-6]. In the present study fracture behavior of laminate veneer of two lithium disilicate materials (e.max CAD and e.max Press) were tested with different marginal preparation design in an in-vitro study.

Lithium disilicate ceramics were chosen because they have the advantage of long-term clinical acceptability, good bonding characteristics, favorable esthetics and lake for porcelain veneering need [5,8].

Many teeth preparation designs for margin preparation were proposed by varying authors [9]. Tredson et al. [5] have reported that the direction of the chewing force on teeth is more significant for success of restoration than type of preparation. In the present study, the selection of two design (Chisel and 0.3 mm Chamfer) was to evaluate a possible influence of the marginal preparation design on the fracture resistance of the restoration.

The decision of using epoxy resin material to be the abutment used in this study is due to difficulty in standardization of size and form when as compared to using natural teeth [19]. Epoxy resin material is easier to be standardized and has modulus of elasticity comparable to the human dentin and have several important advantages including strength, abrasion resistance, and detail reproduction [20].

The CAD/CAM technology was chosen due to its ability to control thickness and anatomy of restorations during the fabrication process. It also allowed the standardization of the design and anatomy of each preparation design in (CAD/CAM) and press samples [4-6].

Resin cement was used for cementation of laminate veneers on the epoxy dies. The reinforcing effect of adhesive cementation was demonstrated with 40% increase in flexural strength by applying resin cement to etched glass ceramics.

The results of the present study were significantly affected by the construction technique as well as the preparation design of the ceramic veneers [21].

The significant higher fracture resistance values of IPS e.max CAD over IPS e.max press may be due to the smoother surface and minimal inherent flaws. Also, using the same ceramic material in the form of industrial prefabricated blocks and applying the milling technique increase the Weibull modulus of oxide ceramics, and thus the reliability of the restorations was significantly enhanced[8]. These results were in agreement with Mohamed H. Riad et al [22]. who's found that increase fracture resistance for the IPS e.max CAD than IPS e.max Press. Also, in agreement with Jung et al [23] who's explained the higher fracture force based on the fact that the industrially pre-fabricated In-Ceram core material has more homogeneous microstructure and 10% flexural strength than the conventional core material.

Another study conducted by Petra C et al [24], stated that IPS e.max CAD crowns showed fracture loads greater than e.max press in most of available literature.

However, the results by Alkadi et al [25] showed that: IPS e.max Press has higher fracture resistance than IPS CAD and justified that by IPS e.max CAD had a smooth surface and the crack seemed to propagate within the glassy matrix and that may be due to improper crystallization after milling of IPS e.max blocks.

Also, the results regarded to the preparation design showed that the more conservatism in laminate veneer preparation afforded more surface area for bonding which is important for laminate veneer fracture resistance[6].

This results are supported by Castelnuovo J et al [26] results which showed less invasive preparations led to decrease mode of failure. And Imburgia et al [27] who stated in one year follow up laminate veneer clinical case a good clinical result when e.max Press used with vertical preparation design, thus enriched by the significant difference of the two preparation was found only in Press samples which have more irregular fitting surface that increase surface area of bonding between laminate veneer and abutment. Thus is more conservatism in Press samples has a more significant difference than in CAD samples.

CONCLUSIONS

Within the limitation of this study, the following conclusions can be drawn:

1. The technique of fabrication of ceramic laminate veneer restorations has a crucial effect on its performance with the regard to fracture resistance. IPS e.max CAD could be considered as a valid restoration than IPS e.max press.
2. The fracture resistance of laminate veneers is influenced by different cervical margin preparation designs. The more conservative preparation, the more is the fracture resistance of the restoration.

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