RUHS Journal of Health Sciences, Volume 3 Number 2, April-June 2018

Original Article

10.37821/ruhsjhs.3.2.2018.88-93

Influence of Different Preparation Designs on Fracture Strength of Porcelain Laminate Veneer

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ABSTRACT

Introduction: Porcelain laminate veneers are widely used as an esthetic restoration of anterior teeth. However, limited information is available regarding the influence of preparation design on fracture strength of veneers. The study was done to evaluate the effect of different preparation designs on fracture strength of porcelain laminate veneers made of lithium disilicate glass ceramic.

Methodology: The study included 40 extracted maxillary central incisors which were divided into four groups. Different preparation designs tested were window preparation (WP) with no incisal reduction, incisal overlapped preparation (IOP) including 2 mm incisal reduction without palatal chamfer, and complete veneer preparation (CVP) including 3 mm incisal reduction and 2 mm palatal extension. Intact natural teeth served as control. Thirty Ivoclar Porcelain System (IPS) e.max ceramic veneers were bonded adhesively with dual-polymerizing resin cement (Variolink II, Ivoclar Vivadent Inc. Schaan, Liechtenstein). Tooth integrity was evaluated under compressive loading, using a Universal Testing Machine. Data gathered was subjected to paired t test and t-test for equality of means and Levene's test for equality of variances.

Results: Mean fracture load values were as follows: WP - 1066 N, IOP - 1441 N, CVP - 920 N and control - 1503 N. IOP showed statistically significant higher fracture load values when compared with WP and CVP.

Conclusion: Maxillary central incisor when prepared with incisal overlapped preparation design and restored with lithium disilicate glass ceramic exhibited fracture strength similar to the unprepared tooth.

INTRODUCTION

Porcelain laminate veneers were introduced to dentistry during the late 1930s. Since then, the spectrum of clinical indications of porcelain laminate veneer has been expanding. This increase in the popularity of these restorations can be attributed to an era of "minimal invasive dentistry" as well as a result of recent technical and experimental acquisitions.

A study reported that porcelain laminate veneers are indicated exclusively to restore esthetics and not function.[1] However, Friedman[2] contradicted this view by suggesting their use not only as excellent esthetic restorations but also as restorations providing reliable functional strength. He also suggested that they can be used to provide anterior guidance by restoring appropriate incisal length. Current beliefs support removal of varying amounts of tooth structure for porcelain laminate veneers.[3,4] Quinn et al[5] recommended laminate veneer preparation without shortening of the tooth in order to place the incisal finish line labial to the contact areas. Calamia[6] preferred an incisal reduction to form a slight overlapping. However, there is no consensus in the literature as to whether or not the incisal edge should be included in the preparation for a porcelain laminate veneer.[7,8]

On the basis of various studies[9,10] three basic types of preparation designs have evolved over the years namely, the window or intra-enamel preparation (WP), the incisal overlapped preparation (IOP), and the complete veneer (palatal overlap) preparation (CVP) as shown in figure 1.

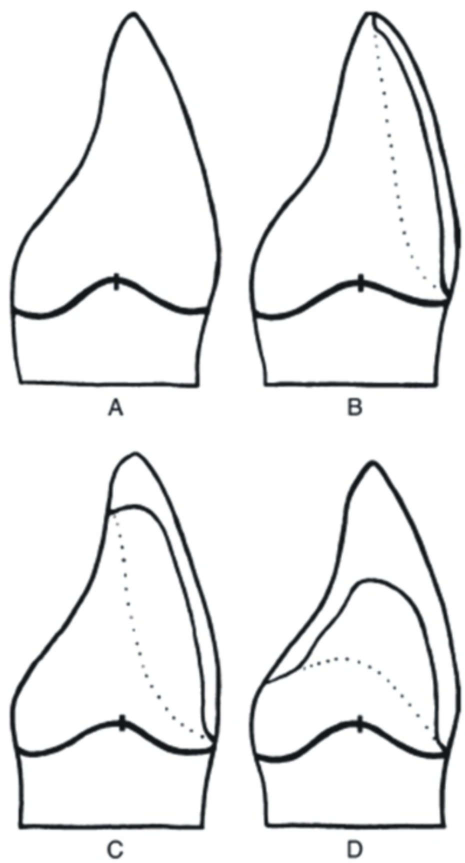

Figure 1: Schematic representation of different preparation designs for porcelain laminate veneers.[11]

Natural tooth (A), window preparation (B), incisal overlapped preparation (C), complete veneer preparation (D).

The purpose of this study was to evaluate and compare the influence of different preparation designs on fracture strength of porcelain laminate veneers made of lithium disilicate glass ceramic.

METHODS

The present study was conducted at Nair Hospital Dental College, Mumbai. 40 freshly extracted permanent maxillary central incisors with 10±0.5 mm anatomic crown length and comparable mesiodistal and facio–palatal dimension were collected. Each tooth was free of dental caries and restorations. These were stored in 10 percent formalin[12, 13] for one week for disinfection and then stored in normal saline at room temperature except during tooth preparation, impression making, cementation and testing procedures.

Each tooth was embedded 2 mm below cemento enamel junction (CEJ) in auto polymerizing acrylic resin block of 2x4 cm. 40 specimens were then divided into four groups of 10 specimens each and numbered as follows:

Group A: Window preparation with no incisal reduction

Group B: Incisal overlapped preparation with 2 mm incisal reduction and without palatal chamfer

Group C: Complete veneer preparation with 3 mm incisal reduction and 2 mm palatal extension

Group D: Unrestored intact teeth as control

A silicone mold (Addition silicone: putty- Elite HD + Putty, Zhermack, Italy) of each abutment tooth was made before preparation and was used to standardize the preparation procedure. All preparation designs included the proximal tooth surfaces upto the contact area. The facial, palatal, and proximal surfaces were reduced by 0.5 mm. Reduction uniformity was achieved by placing depth grooves using a self-limiting depth-cutting three tiered diamond bur of 0.5 mm. The remaining tooth structure was reduced in accordance; using 1.0 mm chamfer diamond bur. Cervical finish lines were prepared 1 mm incisal to the cemento-enamel junction. Tooth preparations were evaluated using respective silicone molds of the teeth (Figure 2).

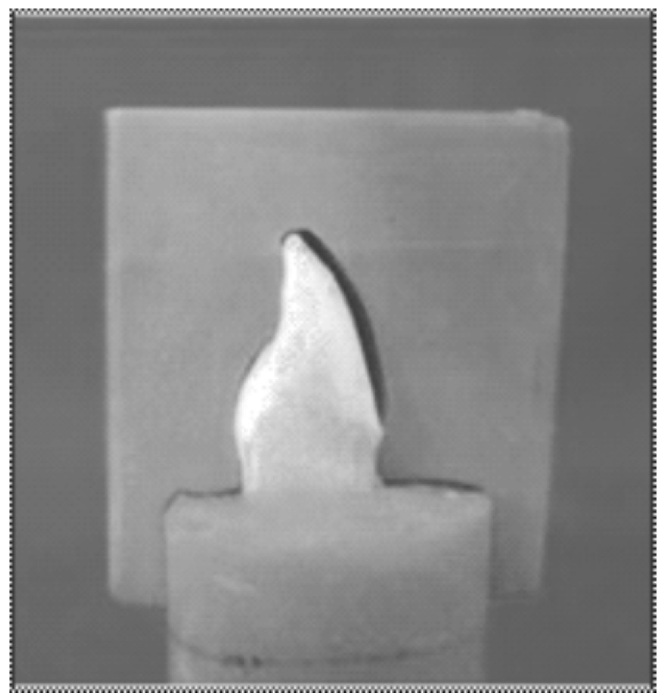

Figure 2: Prepared specimen.

As metal is more rigid than resin, metal impression tray was used for making impressions. Tray was coated with tray adhesive to provide retention for the impression. Impressions were made with vinyl polysiloxane (Addition silicone: putty and light body- Virtual, Ivoclar Vivadent, Schaan, Liechtenstein) using double mix technique (Figure 3).

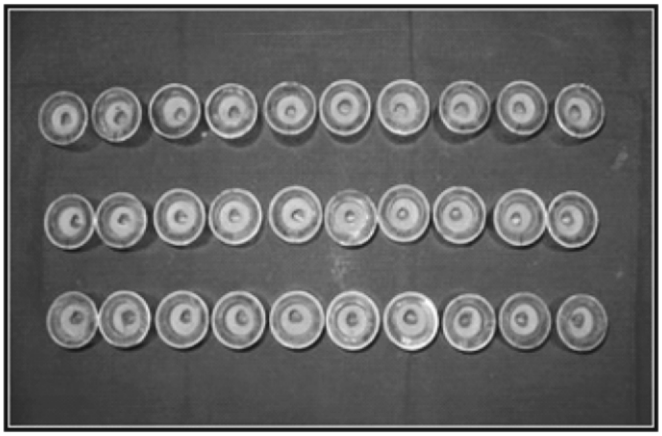

Figure 3: Impressions of the prepared teeth.

Surfactant (True-Blue, USA) was sprayed on the impression surface to increase the wettability. Impressions were then poured in type IV dental stone (Ultrarock, Kalabhai). After application of die hardener, 2 coats of die spacers were painted 0.5 mm short of the finish lines of the preparations. Two coats of die lubricant were then applied to each die. Prepared dies are shown in figure 4.

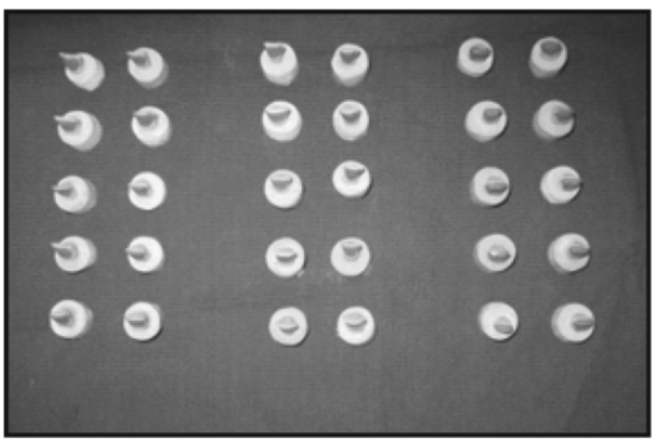

Figure 4: Prepared dies.

All 30 veneers in groups A through C were waxed to a uniform thickness of 0.5 mm with beige wax and sprued with sprues of 3 mm thickness and 5 mm length (Figure 5). 4-5 laminate patterns were attached to one ring base former taking care that they were at an angle of 45º–60º to base former and at least 10 mm away from each other. Each ring was invested immediately to prevent distortion. IPS Press VEST speed investment powder and liquid were mixed together following the manufacturer's instructions (100 gm powder: 27 ml diluted liquid).

Investment cylinders were preheated in a conventional preheating furnace to a final temperature of 85ºC for 30

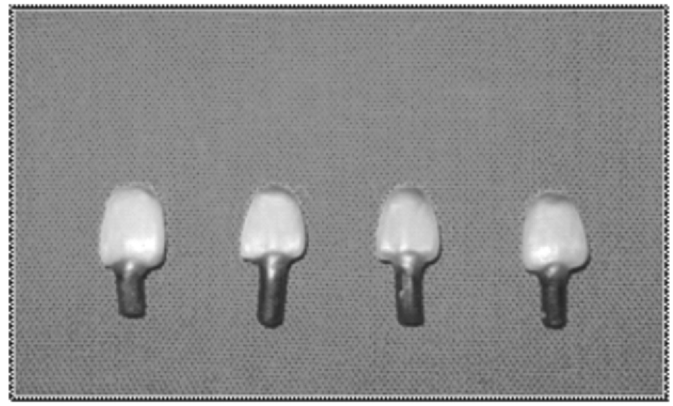

Figure 5: Wax patterns attached to the sprues.

minutes. A hot press furnace (IPS Empress EP 600; Ivoclar Vivadent) was used for the pressing procedure. Lithium disilicate glass-ceramic (IPS e.max Press, Ivoclar Vivadent) was used to fabricate porcelain laminate veneers (Figure 6). Pressing was done at a temperature of 105ºC. After divestment, the pressed veneers were cut from the sprues and cleaned. Veneer fit and thickness were verified on the die and then on abutment using respective silicone mold.

Figure 6: IPS e.max Press ingots and divested and sandblasted laminates.

Traditional luting procedure was performed. The intaglio surface of the restoration was etched for 20 seconds with 5% hydrofluoric acid (IPS Ceramic etchant; Ivoclar Vivadent), rinsed and dried. A silane coupling agent (Monobond S; Ivoclar Vivadent) was then applied to the etched surface for 60 seconds and air dried. Teeth were cleaned initially with a rotating rubber cup and polishing paste and then rinsed, dried, and etched with 37% phosphoric acid (Total Etch; Ivoclar Vivadent). After etching for 15 seconds, teeth were again rinsed and dried. A dentin adhesive (Tetric N Bond; Ivoclar Vivadent) was then applied to the prepared tooth surface and cured for 20 seconds. Restorations were luted with a dual-polymerizing resin (Variolink II; Ivoclar Vivadent). Porcelain laminate veneers were tack cured for 10 seconds. Then excess cement was removed with a scalpel. Fit and orientation of laminate was again verified using silicone mold. The porcelain laminate veneers were then light polymerized using a L.E.D. polymerizing unit (Gnatus, Brazil) for 40 seconds. Finishing was performed using finishing stones and polishing cups (Shofu Dental Corp., Japan).

Specimen testing was done at IIT, Mumbai. Specimens were loaded on the incisal edge along the long axis of the tooth. The fracture load (N) was determined using a Hounsfield Universal Testing Machine at a cross head speed of 1.5 mm/minute. For homogeneous stress distribution, a 1 mm thick piece of tinfoil was placed between the incisal edge and the loading point. The load at failure was recorded for each test specimen where load was defined as a bulk fracture of a specimen.

RESULTS

The fracture load values (N) of the four groups- WP (Group A), IOP (Group B), CVP (Group C) and unprepared control (Group D) are summarized in table 1. The fracture load means and standard deviations for the three designs of porcelain laminate veneers and the unrestored control are shown in figure 7. Mean fracture load value for WP was 1066.6 ± 119.94N, for IOP was 1441.6 ± 121.50N, and for CVP was 920.7 ± 93.78N. Unprepared control group exhibited mean fracture load of 1503.0 ± 105.85N.

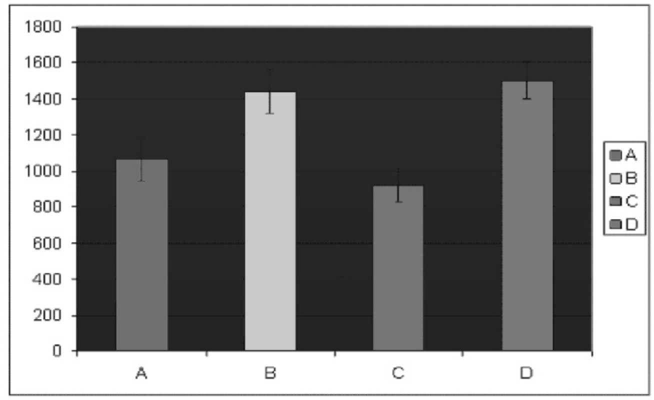

Figure 7: Comparison of mean and SD of fracture load values (N) of different preparation designs for porcelain laminate veneers.

A-Window preparation; B- Incisal overlapped preparation; C-Complete veneer preparation; D-Control.

Data gathered was subjected to statistical analysis. The software used for statistical analysis of the data was SPSS version 15.0. Paired t test was applied. Level of significance was set at $p < 0.05$. IOP showed statistically significant higher fracture load values than WP and CVP. WP showed statistically significant higher fracture load values than CVP.

Table 1: Fracture load values (N) of study groups

Sample Number	Group A	Group B	Group C	Group D
1	902	1635	805	1675
2	1068	1552	937	1587
3	1045	1425	986	1438
4	1128	1483	812	1582
5	1295	1457	1075	1497
6	990	1205	972	1312
7	1005	1443	863	1512
8	1092	1307	1015	1524
9	1204	1512	817	1376
10	937	1397	925	1527

Table 2: Comparison of fracture load values of study groups

		Paired Differences							
		Mean	S D	Std. Error Mean	95% Confidence Interval of the Difference		t (df = 9)	p value
					Upper	Lower		
Pair 1	A-B	-375.00	167.57	52.99	-494.87	-255.12	-7.07	0.000
Pair 2	A-C	145.90	125.50	39.68	56.11	235.68	3.67	0.005
Pair 3	A-D	-436.40	179.14	56.65	-564.55	-308.24	-7.70	0.000
Pair 4	B-C	520.90	189.85	60.03	385.08	656.71	8.67	0.000
Pair 5	B-D	-61.40	91.52	28.94	-126.87	4.07	-2.12	0.063
Pair 6	C-D	-582.30	161.49	51.06	-697.82	-466.77	-11.40	0.000

Table 3: Pearson correlation for fracture load values of study groups

		Group A	Group B	Group C
Group D	Pearson Correlation	-0.256	0.684(*)	-0.306
	p value	0.475	0.029	0.390
	N	10	10	10

* Correlation is significant at the 0.05 level (2-tailed).

Fracture load for IOP was comparable to the control group (Table 2). Pearson correlation between WP, IOP, CVP, and control are shown in table 3. Strong positive correlation was found between IOP and control. Different patterns of fractures observed were root fractures, facial fractures, incisal fractures, and also longitudinal fractures. Most of the fractures involved both laminate and tooth.

DISCUSSION

In this study, freshly extracted human incisors were used to optimally represent the clinical situation. Human teeth were preferred over artificial teeth or bovine teeth, which differ from human teeth in elasticity, bonding properties, thermal conductivity, and strength.[8,14] Extracted human teeth, however, have a large variation in size, shape, and quality.[15] Therefore, measures were taken to standardize the size of the teeth with the selected teeth having an anatomic crown length measuring 10 ± 0.5 mm and comparable mesio–distal and facio-palatal dimension. A reduction of 0.5 mm in 40 teeth used in this study was observed , which is recommended for porcelain laminate veneers.[9,16,17] Tooth preparation for porcelain laminate veneers was carried out with the help of depth cutting bur of 0.5 mm depth cut. The remaining tooth structure was reduced in accordance, using 1.0 mm chamfer diamond bur. The freehand preparation can result in variable depth of preparation.[18] Tooth preparation was standardized and controlled with a silicone mold to minimize variation. The specimens were subjected to compressive loading using a Universal Testing Machine (Hounsfield) at crosshead speed of 1.5 mm / minute.

Failure load for porcelain laminate veneers has also been measured by different authors with different proto cols.[7,10,19,20] In the present study the failure load was measured by loading the veneer-tooth complex directly at the incisal edge and in a direction parallel to the long axis of the tooth to stress the tooth through the veneer restoration and to obtain reproducible results.[10,21]

Highton R et al[21] reported that including incisal edge in the preparation provides a wide vertical stop that results in wider distribution of incisal load thus reducing concentration of stress. Conversely, Hui et al[10] suggested that overlapping will direct stress on to the veneer, increasing the chances of fracture. In a clinical study, no correlation was found between the survival rate and different incisal preparation designs after 2.5 years.[22]

In the present study, incisal overlapped preparation showed statistically significant higher fracture load values than window preparation and complete veneer preparation. A strong positive correlation was found between the incisal overlapped preparation and unprepared teeth. Strong correlation was found between IOP and unprepared control. These findings suggest that resistance to fracture was significantly higher for IOP than WP and CVP.

Generally, the fracture strength of a natural tooth is compromised after tooth preparation. It was found that lithium disilicate glass ceramic (IPS e.max Press in this study) along with adhesive cementation, supported the residual tooth structure, applied a good distribution of stresses, and enabled the prepared tooth to reach the fracture strength of unprepared tooth.

The methodology used in this study allowed investigation to be similar to the clinical situation including the abutment tooth, preparation, restoration, and cementation procedure. Longitudinal clinical studies are imperative to determine survival rate and clinical performance of porcelain laminate veneers.

CONCLUSION

Maxillary central incisor when prepared with incisal overlapped preparation design and restored with lithium disilicate glass ceramic exhibited fracture strength similar to the unprepared tooth.

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