EGYPTIAN
DENTAL JOURNAL
www.eda-egypt.org

Vol. 70, 2659:2669, July, 2024

Print ISSN 0070-9484 • Online ISSN 2090-2360

Fixed Prosthodontics and Dental Materials

Submit Date : 18-05-2024 • Accept Date : 26-06-2024 • Available online: 10-07-2024 • DOI : 10.21608/EDJ.2024.290406.3041

EFFECT OF PREPARATION DESIGN ON THE FRACTURE RESISTANCE OF PARTIAL LAMINATE VENEERS. AN IN-VITRO STUDY

Omnia Nabil* *and* Ahmed Soliman Idris*

ABSTRACT

Objectives. To evaluate the effect of two preparation designs of partial laminate veneers on the fracture resistance of anterior teeth with full and half incisal edge fracture.

Materials and Methods. 48 upper central incisors were divided into four equal groups: two groups simulated completely fractured incisal edge: Group (Full/Cham): with chamfer design and Group (Full/Bev): with bevel design and two groups simulated half fractured incisal edge: Group (Half/Cham): with chamfer design and Group (Half/Bev): with bevel design. Lithium disilicate partial veneers were constructed and cemented using light-curing resin cement. All samples were mounted on universal testing machine to test their fracture resistance. Fractured samples were categorized as restorable or non-restorable based on the crack/fracture extension relative to the cemento-enamel junction.

Results. Group (Full/Cham): (361.05 ± 11.39 N) had significantly the highest fracture resistance, followed by Group (Full/Bev): (207.1 ± 10.85 N), while Group (Half/Cham): (123.16 ± 6.63 N) and Group (Half/Bev): (123.75 ± 6.12 N) had significantly the lowest values with insignificant difference between them. All teeth with half incisal edge fracture revealed restorable fractures, while with full incisal edge fracture the percentage dropped to third (33.3%).

Conclusions. In full incisal edge fractures, chamfer design had better fracture resistance than bevel design. While in half incisal edge fractures, both designs had similar fracture resistance and restorable mode of failure.

Clinical Relevance. The innovative chamfer and bevel designs of partial laminate veneers can be used as a highly conservative approach to restore anterior teeth with full or half fractured incisal edge.

KEYWORDS. Partial laminate veneer, Chamfer design, Bevel design, Lithium disilicate, Fracture resistance.

* Lecturer, Fixed Prosthodontics department, Faculty of Dentistry, Cairo University, Cairo, Egypt .

Article is licensed under a Creative Commons Attribution 4.0 International License

INTRODUCTION

The fracture of the incisal edge of anterior teeth is common and its restoration has always been one of the most challenging treatment procedures facing clinicians [1,2]. The goal is to provide the patient with the most conservative yet the most esthetically pleasing treatment option [1]. Whenever the fractured detached part is intact, our first option is to reattach adhesively. While if it's lost, we have to do a restoration [3].

Restorative treatments include either the direct composite resin or the indirect ceramic laminate veneer. Direct composite resin has the advantage of being minimally invasive, more conservative technique than ceramic laminate veneer, performed in one visit and relatively inexpensive. However, it is expected to suffer from wear and discoloration over time which compromises esthetics and necessitates their frequent replacement [4-6]. On the other hand, ceramic veneers showed longer survival rates compared to composite restorations [7]. This is attributed to their color stability exceeding ten years of service as well as favorable wear resistance [8,9].

With the uprising moves towards preservation of maximum amount of irreplaceable tooth structure and the great improvement in the bonding, combined with the need for a durable, enamel-friendly, and color stable material, partial ceramic veneers have been introduced [10]. The technicalities of the preparation, construction, finishing and bonding of these veneers are still lacking in literature [11].

During tooth preparation to receive partial ceramic laminate veneers (PCLVs), almost no sound tooth structure is removed. The lost part only whether all or part of the incisal edge is reestablished by additive concept. The junction between partial veneer and sound tooth structure (finish line) might influence the fracture resistance as well as the survival rate of these restorations [12]. The present study aimed at introducing two preparation designs of PCLVs (chamfer and bevel) and evaluating their effect on the fracture resistance of anterior teeth in cases of Full (complete) and half (partial) incisal edge fractures.

The first null hypothesis was that there would be no significant difference in the fracture resistance of anterior teeth of full and half incisal edge fractures when restored with partial ceramic veneers. The second null hypothesis was that there would be no significant difference between the chamfer and bevel preparation designs of partial ceramic laminate veneers in the fracture resistance of restored anterior teeth.

MATERIALS AND METHODS

This research was conducted in the Department of Fixed Prosthodontics at Cairo University. The study had been approved by the faculty ethics committee (17423).

Sample size calculation

This power analysis used fracture strength (N) as the primary outcome. Gresnigt et al. [2] in 2021 carried out a study and its results showed that the control group's mean and standard deviation values were 266 ± 69 N. Based upon expert opinion; the estimated mean difference between experimental and control groups will be 84 N. Using alpha (α) level of (5%) and Beta (β) level of (20%) i.e., power = 80%; the minimum estimated sample size was 12 restorations per group giving a total of 48 restorations. Sample size calculation was performed using PS Power and Sample Size Calculations Version 3.

Materials

The names, types, manufacturers, and chemical compositions of materials used in this study are listed in **(Table 1)**.

TABLE (1) The names, types, manufacturers, and chemical compositions of materials used in this study.

Name	Type	Manufacturer	Composition
IPS e-max press	Lithium Disilicate Glass Ceramic	Ivoclar Vivadent, Schaan Liechtenstein	SiO_2, Li_2O, K_2O, P_2O_5, ZrO_2, ZnO, other oxides and ceramic pigments
9.5% Porcelain Etchant	Glass ceramic acid etchant	Bisco, USA	Polyacrylamidomethylpropane sulfonic acid, hydrofluoric acid,7%<=conc<=60%, aqueous solutions
Porcelain Primer	Silane coupling agent	Bisco, USA	3-(Trimethoxysilyl) propyl-2-Methyl-2-Propenoic Acid
Select HV® Etch w/BAC	Tooth Etchant	Bisco, USA	Phosphoric Acid, conc=85%, Benzalkonium Chloride
All Bond Universal	Tooth Bonding agent	Bisco, USA	BisGMA, 2-Hydroxyethyl Methacrylate, 10-Methacryloyloxydecyl Dihydrogen Phosphate, Ethyl 4-dimethylaminobenzoate
Choice 2	Veneer Cement	Bisco, USA	Urethane Dimethacrylate, BisGMA, Tetrahydrofurfuryl Methacrylate

Teeth collection and grouping

Sound human upper central incisors were collected from the outpatient clinic of Oral surgery in Faculty of Dentistry, Cairo University. Upper central incisors with close resemblance in dimensions were chosen such that their crown length was (11±0.5 mm), crown width was (8.5±0.2mm) and root length was (15.2±0.5 mm). All teeth were examined carefully to end up with 48 upper central incisors free of caries, fractures and without endodontic treatments or any restorations. Teeth were then randomly divided into four groups (n=12):

Group (Full/Cham): PCLVs with chamfer design restoring completely fractured incisal edge.

Group (Full/Bev): PCLVs with bevel design restoring completely fractured incisal edge.

Group (Half/Cham): PCLVs with chamfer design restoring half fractured incisal edge.

Group (Half/Bev): PCLVs with bevel design restoring half fractured incisal edge.

All the teeth were placed in containers filled with distilled water. They were kept at room temperature and every week the water was replenished.

Teeth Preparation

Incisal edge preparation:

In Groups (Full/Cham) and (Full/Bev): 2 mm preparation of incisal edge was done to resemble full incisal edge fracture with a diamond bur ISO 856018 (Diatech, Switzerland).

In Groups (Half/Cham) and (Half/Bev): 2 mm preparation was restricted to half the incisal edge only with a diamond bur ISO 856018 (Diatech, Switzerland).

Labial surface preparation:

Preparation of labial surface was restricted to the incisal third of tooth. Orientation grooves of 0.3 mm depth were made at the incisal third. Subsequently, the grooves were merged providing a continuous labial surface preparation.

- Group (Full/Cham): preparation involved the whole width of inciso-labial surface with a shallow chamfer finish line of 0.3 mm thickness **(Fig. 1).**
- Group (Full/Bev): preparation involved the whole width of inciso-labial surface with a bevel finish line of 0.1 mm thickness **(Fig. 1, 2).**

- Group (Half/Cham): preparation involved half the inciso-labial surface with a shallow chamfer finish line of 0.3 mm thickness **(Fig. 3).**
- Group (Half/Bev): preparation involved half the inciso-labial surface with a bevel finish line of 0.1 mm thickness (**Fig. 3, 4).**

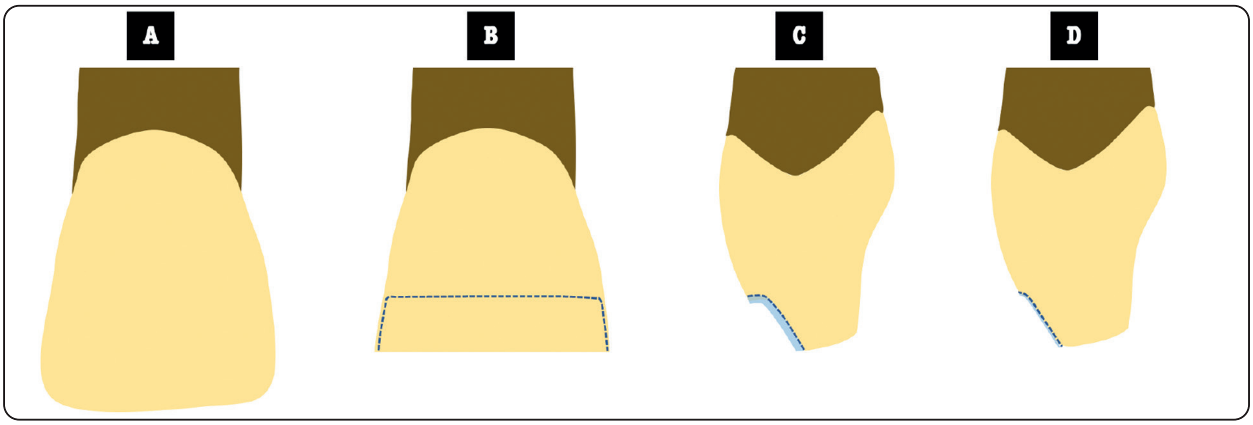

Fig. (1) Diagram showing A. Sound upper central incisor. B. Preparation resembling full incisal edge fracture C. Side view showing 0.3 mm chamfer finish line D. Side view showing 0.1 mm bevel finish line. Blue dots denote the outline of the prepared area.

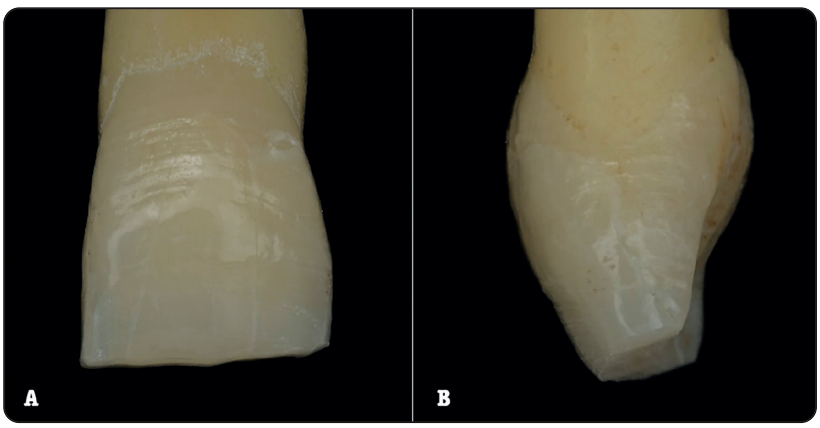

Fig. (2) Tooth preparation of group (Full/Bev), A. Front view, B. Side view

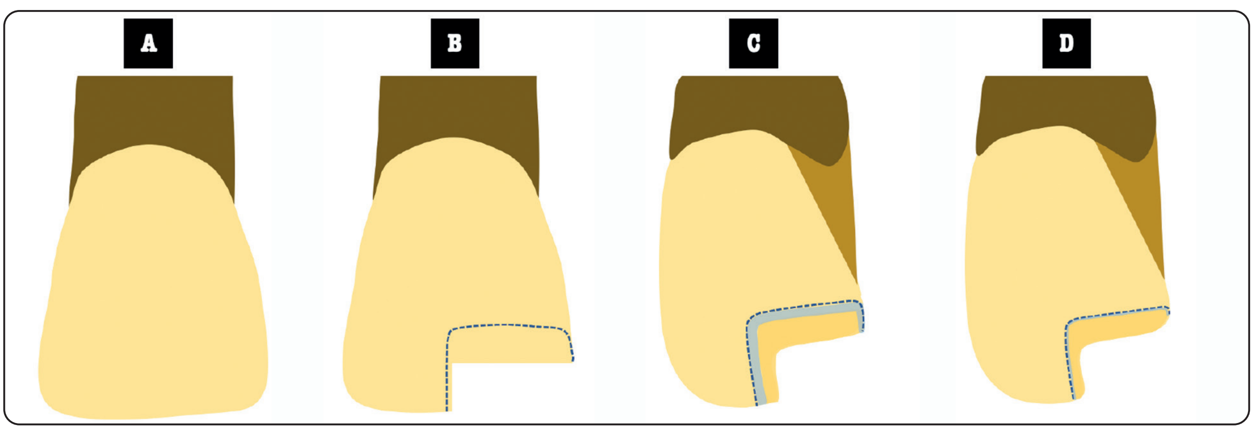

Fig. (3) Diagram showing A. Sound upper central incisor. B. Preparation resembling half incisal edge fracture C. Group (Half/Cham) with 0.3 mm chamfer finish line D. Group (Half/Bev) with 0.1 mm bevel finish line. Blue dots denote the outline of the prepared area.

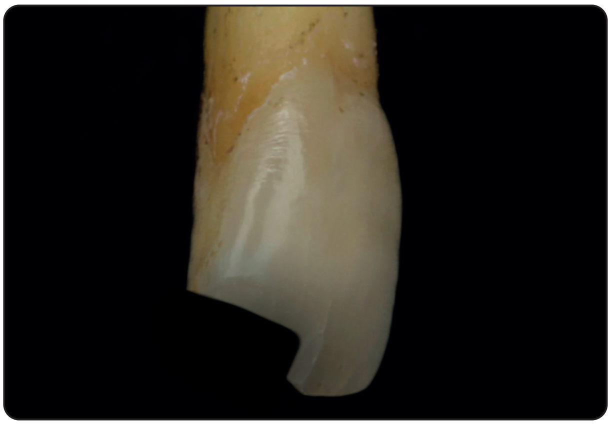

Fig. (4) 2 mm Half incisal edge fracture with bevel finish line.

Construction of PCLVs

In our study, lithium disilicate (LDS) was preferred to be produced by pressable technique rather than CAD/CAM. Partial ceramic laminate veneers were made of pressable lithium disilicate glass ceramic by one dental technician. Wax patterns were constructed from modeling wax (Renfert, Germany) with an electric wax dropper (Renfert, Germany) using the add-on technique. The build-up was completed, and the dimensions of the wax patterns were checked and verified, then the thickness of the wax patterns was confirmed using a digital caliper. Reflowing of the marginal wax was done, then wax patterns were sprued and invested according to the manufacturer instructions. Pressing of IPS e-max ceramic ingots (IPS e-max press HT, Ivoclar Vivadent AG, Schaan, Liechtenstein) was done under controlled heat and pressure in a pressing furnace (Programat EP3000; Ivoclar Vivadent AG) after wax elimination to produce properly adapted restorations [13]. The restorations were finished and polished following the manufacturer's instructions.

Bonding of PCLVs

Tooth surface treatment: enamel was acid etched for 30 seconds with phosphoric acid 37% (Select HV® Etch w/BAC, BISCO). After rinsing for 60 seconds and gently air-drying, a universal bonding agent (All Bond Universal, BISCO) was applied to the entire preparation following manufacturer's instructions.

Veneer surface treatment: the internal surface of restorations was etched with buffered hydrofluoric acid (9.5% Porcelain Etchant, BISCO) for 20 seconds, thoroughly rinsed with water and ultrasonic cleaning was done in distilled water for 5 minutes. After air-drying, 37% phosphoric acid was used with active rubbing for 30 seconds to neutralize the surface from the reactive precipitates of the hydrofluoric acid, then silane coupling agent (Ceramic Primer, BISCO) was applied with active rubbing for 20 seconds using a bond brush, left for 1 minute and then air dried.

Cement application: The light-curing veneer resin cement (Choice 2, BISCO) was applied on the tooth and in the fitting surface of the veneer. Each veneer was seated on its corresponding preparation and tack light curing was performed for 2 seconds (Bluephase N, Ivoclar Vivadent) (1220 mW/cm2). The excess resin cement was removed with a scaler and glycerin gel (Liquid Strip, Ivoclar Vivadent) was applied around the outline and another 40 seconds of light curing were performed. The outline was then polished with small flame cups (Ivoclar Vivadent) (**Fig. 5).**

Teeth mounting

The root of each tooth was immersed in a plastic ring (2.5 cm in diameter and 2 cm in length) filled with epoxy resin (CMB, Egypt). A specially designed paralleling device was used to hold the teeth in a centralized vertical position in the ring until the resin had completely set. The position of the cementoenamel junction at the middle of the labial surface was fixed at 2 mm away from the epoxy resin surface.

Fracture resistance test

Static load to failure was applied without the inclusion of any variables [14]. This test offered standardization and observation of failure mode [15].

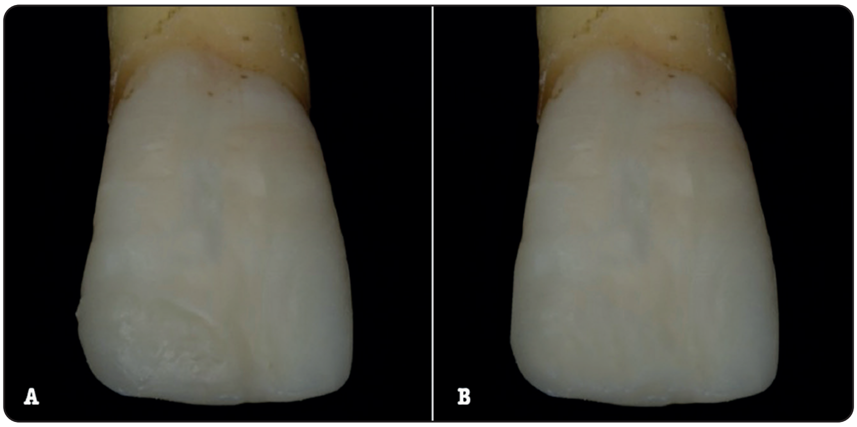

Fig. (5). Partial ceramic laminate veneer (Group Half/Bev): A: immediately after cementation on its corresponding tooth, B: After finishing and polishing.

Each sample was put in a specially designed 45^{o} angle jig and stabilized by screws in the lower fixed component of the universal testing machine (Instron Model 3345; Instron Industrial Products, Norwood, MA, USA) with a loadcell of 5 kN and data were recorded in N using computer software (Instron® Bluehill Lite Software). A 3.4 mm diameter round end metallic rod that moved at crosshead speed of 1mm/min delivered the load in a compressive way at 135^{o} angle palatally.

Tin foil sheet was placed between the tooth and the rod to attain uniform stress distribution and reduce the transmission of local force peaks. The maximum load to failure was evident by a clearly heard sound of a crack, detected on software by an abrupt fall at load-deflection curve. The recorded data were arranged in tables and then analyzed statistically.

Failure mode

Examining the modes of failure provides a clinical perspective to invitro investigations and identifies the restorability of the fractured tooth [16]. The mode of failure of the fractured samples was evaluated under magnification using Leica MZ6 Stereomicroscope (Meyer Instruments, USA). The failure mode was classified as restorable where the recorded crack/fracture was above the cementoenamel junction (CEJ), or non-restorable when the crack/fracture extended beyond CEJ.

Statistical analysis

Statistical analysis was performed using SPSS 16 ® (Statistical Package for Scientific Studies), Graph pad prism & windows excel. Exploration of the given data was performed using Shapiro-Wilk test and Kolmogorov-Smirnov test for normality which revealed that all data originated from normal distribution (parametric data) resembling normal Bell curve. Accordingly, quantitative data comparison between different groups was performed by using One Way ANOVA test followed by Tukey`s Post Hoc test for multiple comparisons, while comparison between 2 groups was performed by using Independent t test. Comparison between effect of 2 variables was performed by using Two Way ANOVA test. In qualitative data all comparisons were performed by using the Chi square test. Significance level was set to $p \leq 0.05$.

RESULTS

Fracture resistance:

Comparison between all groups revealed significant difference, as Group (Full/Cham) (361.05 ± 11.39 N) was significantly the highest, followed by Group (Full/Bev) (207.1 ± 10.85 N), while Group (Half/Cham) (123.16 ± 6.63 N) and Group (Half/Bev) (123.75 ± 6.12 N) were significantly the lowest with insignificant difference between them **(Table 2).**

TABLE (2) Descriptive results of all groups and comparison between them regarding fracture resistance using One Way ANOVA test followed by Tukey`s Post Hoc test.

Edge	Design	Min (N)	Max (N)	Mean (N)	SD (N)	P value
Full incisal edge	**Chamfer**	347.9	374.6	361.05 [a]	11.39	<0.0001*
	Bevel	195.6	220.8	207.10 [b]	10.85	
Half incisal edge	**Chamfer**	114.5	129.4	123.16 [c]	6.63	
	Bevel	116.8	131.1	123.75 [c]	6.12	

Max, maximum; Min, minimum; SD, standard deviation.

Means with the same superscript letters were insignificantly different as P>0.05.

Means with different superscript letters were significantly different as P≤0.05.

Regarding the effect of incisal edge on fracture resistance, comparison between different incisal edges revealed that full incisal edge (284.1 ±79.38 N) had significantly higher fracture resistance than half incisal edge (123.5 ±6.24 N).

Regarding the effect of design on fracture resistance, comparison between different finish line designs revealed that chamfer (242.1±121.8 N) was significantly higher than bevel (165.4±43.43 N).

Upon evaluation of different variances effect on fracture resistance, Two-way ANOVA test revealed that both finish line design and incisal edge had significant effects on fracture resistance **(Table 3).**

Failure mode:

Comparison between different groups represented that all teeth with half incisal edge fracture revealed fractured tooth and restoration above cementoenamel junction (CEJ), while 66.7% of teeth with full incisal edge fracture revealed fractured tooth and restoration below CEJ **(Table 4).**

TABLE (3) Two-way ANOVA analysis for the effect of different variables on mean fracture resistance.

Two Way ANOVA table	Sum of Squares (SS)	DF	Mean square (MS)	F value	P value
Design effect	70567	1	70567	858.8	<0.0001*
Incisal edge effect	309579	1	309579	3768	<0.0001*
Interaction Design X Incisal edge	71645	1	71645	871.9	<0.0001*

DF: Degree of Freedom. *P value is significant at P ≤ 0.05*

TABLE (4) Frequency and percentages of different failure modes in groups with different designs and comparison between them using Chi square test.

Failure mode pattern		Fractured tooth and restoration above CEJ		Fractured tooth and restoration below CEJ		P value
		N	**%**	**N**	**%**	
Full incisal edge	**Chamfer**	4	33.3	8	66.7	0.11
	Bevel	4	33.3	8	66.7	0.11
Half incisal edge	**Chamfer**	12	100.0	0	0	<0.0001*
	Bevel	12	100.0	0	0	<0.0001*
P value		0.007*		0.007*		

N: count *%: percentage* *P value is significant at P ≤ 0.05*

DISCUSSION

Lately, minimal invasive solutions have taken the lead in dentistry. Unlike traditional concepts of extensive preparation to increase the macroretention of restorations, conservative preparations saved the maximum amount of remaining tooth structure and relied solely on adhesive bonding for retention [6].

One of the approaches of minimal invasive dentistry is the use of partial ceramic laminate veneers (PCLVs) or glass ceramic fragments to replace small fractures or defects of anterior tooth structure [10].

PCLV treatment option has gained popularity among patients who are keen to gain the best esthetics with no/minimal loss of their tooth structure. Although, composite restorations would offer excellent results, but it is considered only short-term solution due to the changes in color, brightness and surface integrity over time [6].

Glass ceramics offer the advantage of superior esthetics with regards to shade and surface texture. Moreover, using silica-based ceramics with partial veneers preparations plays a key role in adhesive bonding of these veneers to the underlying tooth structure which is expected to enhance the biomechanical performance of the restored tooth [10].

Upon comparing feldspathic ceramics to lithium disilicate ceramics (LDS), LDS have better mechanical properties together with the comparable esthetic characteristics thus giving them the credit of higher predictable clinical longevity [6].

In our study, LDS was preferred to be produced by pressable technique rather than CAD/CAM. This was supported by the advantage of the pressing technique to produce the exact design of the wax pattern, which is built on and properly adapted at the margin (margination) on the die. Controlled heat and pressure generates a well-adapted restoration[13]. While with the CAD/CAM method, we might face the possibility of chipping of thin restoration margins during milling procedure which would be reflected in the decreased marginal adaptation [17].

The distribution of stresses throughout the veneer-tooth complex is affected by variations in preparation designs [18]. Butt joint incisal edge design was done in our study for its preservation of the enamel which serves to resist shear stresses and adds to the adhesive bonding of the restoration. On the contrary, the palatal overlap design had been avoided to save the maximum amount of tooth structure applying the concept of conservatism and to avoid placing thin ceramic extension palatally which could possibly be liable to tensile failure [19].

While for the finish line design of PCLVs in our study, chamfer finish line representing the commonly used design had been compared to the intervention bevel finish line design. Bevel was chosen as a more conservative approach for finish line preparation. Based on the results of **Elgamma et al**,[12] the fracture resistance of laminate veneers covering the whole labial surface of the tooth differed according to the design of the margin cervically, where the chisel margin had higher fracture resistance than 0.3 mm chamfer margin ending up with the conclusion that the more the conservative the finish line preparation, the better is the resistance of the tooth-restoration complex to fracture.

A second reason for selecting this design in our study was that the bevel finish line design was expected to provide color blending property when the restoration is adhesively cemented to tooth structure, thus acting as a valid solution for the recognized slight color mismatch drawback that accompanies the PCLVs with chamfer margins at the interface between the tooth and the restoration. Minimal bevel preparation of the enamel surface was found to create a clear boundary of the extension of PCLV and facilitates its seating. Therefore, eliminating the necessity of a PCLV tooth preparation with chamfer finish line [20].

Bevel margin design of PCLVs restoring full incisal edge fracture and both chamfer and bevel margin designs restoring half incisal edge fracture are considered novel approaches introducing higher levels of conservatism. This study aimed to investigate the influence of these novel preparation designs on the fracture resistance of upper central incisors restored with partial ceramic laminate veneers. The applied fracture test was of static mode as this was found to be reasonable for the primary evaluation of the reliability and structural integrity of these designs while excluding any fatigue confounding variables [14].

The first null hypothesis regarding the effect of extent of incisal edge fracture on fracture resistance was rejected as full incisal edge fracture (284.1±79.38N) had significantly higher fracture resistance than half incisal edge (123.5±6.24N) regardless of finish line design. These results can be explained by the positive effect of increased surface area in case of full incisal edge coverage in the proper seating of PCLV and the increased exposed enamel which aided in the reinforcement of tooth-PCLV complex [15].

Also, the second null hypothesis was rejected as there was significant difference in the fracture resistance of restored anterior teeth with the chamfer design (242.1±121.8N) as compared to the bevel one (165.4±43.43 N). This may be attributed to the strengthening effect of increasing the thickness of glass ceramic brittle material where the bulkier the material, the greater the energy required to lessen the initiation of cracks [16].

The PCLVs resistance to fracture has not been thoroughly investigated. Only **Gresnigt et al**,[2] in 2021 investigated the PCLVs regarding their resistance to failure and found that they had similar values to full ceramic veneers and direct composite ones. The design performed corresponded to Group (Full/Bev) in our study and yielded mean value (266±69N) which was slightly higher than our results (207.1±10.85 N).

Regarding the failure modes of all groups, 100% of half incisal edge samples revealed restorable fractures where the fractured tooth and restoration were above CEJ, while 66.7% of teeth with full incisal edge fracture revealed non-restorable fractures below CEJ. Upon correlating these results with the mean values of fracture resistance of full incisal edge (284.1±79.38 N) and half incisal edge (123.5±6.24 N), the following can be derived; the greater the surface area of bonding of full incisal edge veneers, the better the resistance to failure loads which increased the % of catastrophic failures. On the contrary, the less surface area of bonding of half incisal edge veneers caused the PCLVs-teeth complex to fail at lower loads but at more favorable levels.

Ferrario et al, [21] assessed the single tooth bite forces in healthy young adults aged 19–29 years with full set of permanent teeth. They found that, the incisors received the lowest bite force which increased in an ascending order till the first/second molar. Bite forces were larger in men than in women. Values of upper central incisor were (88±16N – 93±38N) for women and (17±44N – 146±44N) for men.

Considering these values, all designs proposed in our study could be performed safely. Only for young adult males, we should be cautious in case of half incisal edge fracture. In this situation, care should be taken after delivery of the PCLV to eliminate any unnecessary contact points and the patient must be aware of the possibility of the failure of this partial veneer, however, the expected failure would be of reparable type which makes the partial veneer still a favorable treatment option.

Limitations of the current study include the application of static load to failure test without chewing simulation; however, it was reported that the movement of the metallic rod along the palatal surface of natural anterior teeth during chewing simulation may induce cracks or even fractures in the tooth itself rather than the veneer [15].

Future in vivo studies are required to actually evaluate the performance of PCLVs with different designs in the clinical conditions.

CONCLUSIONS

Based on the findings of this in-vitro study, the following conclusions were drawn:

1. In cases of full incisal edge fracture, chamfer design would be recommended as it yielded better fracture resistance than bevel design.
2. In cases of half incisal edge fracture, both chamfer and bevel designs had similar fracture resistance, accordingly, bevel design would be recommended for being more conservative.
3. Teeth with half incisal edge fracture had more favorable failure pattern than teeth with full incisal edge fracture.

DECLARATIONS

Conflict of Interest

Authors have no conflict of interest to declare.

Funding

No funding was obtained for this study.

Ethical Approval

The study had been approved by the ethics committee at the Faculty of Dentistry, Cairo University (Approval number: 17423).

REFERENCES

1. Wiegand, A, Rodig, T, Attin, T. Treatment of crown fractured incisors: reattachment instead of restoration? Schweiz Monatsschr Zahnmed. 2005; 115 (12): 1172–81. German
2. Gresnigt MMM, Sugii MM, Johanns KBFW, van der Made SAM. Comparison of conventional ceramic laminate veneers, partial laminate veneers and direct composite resin restorations in fracture strength after aging. J Mech Behav Biomed Mater. 2021;114: 104172. DOI: 10.1016/j.jmbbm.2020.104172.
3. Anil Kumar S, Radhakrishnan V, Juneja P, Panchneni R. Single visit reattachment of fractured incisal edges using different post systems. Med J Armed Forces India. 2015;71(Suppl 2): S476-80. DOI: 10.1016/j.mjafi.2013.04.011.
4. Van Dijken, J.W.V., Pallesen, U. Fracture frequency and longevity of fractured resin composite, polyacid-modified resin composite, and resin-modified glass ionomer cement class IV restorations: an up to 14 years of follow-up. Clin. Oral Invest. 2010;14 (2): 217-22. DOI: 10.1007/s00784-009-0287-z.
5. Kam Hepdeniz O, Temel UB. Clinical survival of No-prep indirect composite laminate veneers: a 7-year prospective case series study. BMC Oral Health. 2023;23(1):257. DOI: 10.1186/s12903-023-02949-5.

6. Kaptanoglu A, Ordueri T, Kilicaslan A, Kara, H. Minimally Invasive Restoration of Fractured Maxillary Central Incisors with Partial Laminate Veneers- A Case Series. J Clin Diagn Res. 2022; 16(6): ZR01-ZR04. DOI: 10.7860/JCDR/2022/50840.16449.

7. D'Arcangelo, C., de Angelis, F., Vadini, M., D'Amario, M. Clinical evaluation on porcelain laminate veneers bonded with light-cured composite: results up to 7 years. Clin. Oral Invest. 2012; 16 (4): 1071–1079. DOI: 10.1007/s00784-011-0593-0.

8. Vanoorbeek, S., Vandamme, K., Lijnen, I., Naert, I. Computer-aided designed/ computer-assisted manufactured composite resin versus ceramic single-tooth restorations: a 3-year clinical study. Int. J. Prosthodont. 2010 ; 23 (3) : 223–230.

9. Gresnigt, M.M.M., Cune, M.S., Jansen, K., van der Made, S.A.M., ¨Ozcan, M. Randomized clinical trial on indirect resin composite and ceramic laminate veneers : up to 10-year findings. J Dent. 2019 ; 86 : 102–109. DOI: 10.1016/j.jdent.2019.06.001.

10. Durán Ojeda G, Gresnigt MMM, Romero V, Sanhueza V, Wendler M. Clinical report and fractographic analysis of a fractured partial laminate veneer. J Pros Dent. 2022; 10.003. DOI: 10.1016/j.prosdent.2022.10.003.

11. Caetano GM, Slomp C, Andrade JP, Spohr AM, Kunrath MF. Partial Ceramic Veneer Technique for Challenging Esthetic Frontal Restorative Procedures. Dent J (Basel). 2023;11(4):101. DOI: 10.3390/dj11040101.

12. Elgamma MA, Othman HI, Mohamed HR. Effect of two preparation designs and methods of construction on the fracture resistance of glass ceramics laminate veneers. Al-Azhar J Dent Sci 2018;21(4):313-19. DOI: 10.21608/AJDSM.2018.71582.

13. Badami V, Satya Priya M, Vijay L, Kethineni H, Akarapu S, Agarwal S. Marginal Adaptation of Veneers: A Systematic Review. Cureus. 2022;14(11):e31885. DOI: 10.7759/cureus.31885.

14. Shahrbaf S, van Noort R, Mirzakouchaki B, et al.: Fracture strength of machined ceramic crowns as a function of tooth preparation design and the elastic modulus of the cement. Dent Mater. 2014; 30(2): 234–241. DOI: 10.1016/j.dental.2013.11.010.

15. Chai SY, Bennani V, Aarts J and Lyons K. Incisal preparation design for ceramic veneers. J Americ Dent Assoc. 2018; 149: 25-37. DOI: 10.1016/j.adaj.2017.08.031.

16. Elbasty R, Taymour M. (2022). 'Fracture resistance and failure mode of monolithic anterior crowns with two finish line thicknesses. Egypt Dent J. 2022; 68(3):2701-2712. DOI: 10.21608/EDJ.2022.135801.2093.

17. Al-Dwairi ZN, Alkhatatbeh RM, Baba NZ, Goodacre CJ. A comparison of the marginal and internal fit of porcelain laminate veneers fabricated by pressing and CAD-CAM milling and cemented with 2 different resin cements. J Prosthet Dent. 2019; 121:470–476. DOI: 10.1016/j.prosdent.2018.04.008.

18. Tuğcu E, Vanlıoğlu B, Kulak Y, Aslan U. Marginal Adaptation and Fracture Resistance of Lithium Disilicate Laminate Veneers on Teeth with Different Preparation Depths. Int J Periodontics Restorative Dent. 2018; 38(Suppl.): s87-s95. DOI: 10.11607/prd.2995.

19. Arora A, Upadhyaya V, Arora SJ, Jain P, Yadav A. Evaluation of fracture resistance of ceramic veneers with different preparation designs and loading conditions: An in vitro study. J Indian Prosthodont Soc. 2017;17(4):325-331. DOI: 10.4103/jips.jips_37_17.

20. Durán Ojeda G, Naves LZ, Oosterhaven A, Kleinsman R, Bäumer-König A, Körner G, Wendler M, Gresnigt MMM. 8-year multicenter retrospective study on partial laminate veneers. J Prosthodont Res. 2023; 67(2): 206–213. DOI: 10.2186/jpr.JPR_D_22_00079.

21. Ferrario, V.F., Sforza, C., Serrao, G., Dellavia, C., Tartaglia, G.M. Single tooth bite forces in healthy young adults. J. Oral Rehabil. 2004;31(1):18–22. DOI: 10.1046/j.0305-182x.2003.01179.x.