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Effect of Preparation Design on Fracture Resistance of Emax Occlusal Veneers (In vitro study)

Esraa Mahmoud[1], Amina Hamdy[2], Ahmed Abo El Fadl[3]

Aim: the objective of our study is to investigate the effect of two preparation designs on Emax occlusal veneers fracture resistance.

Materials and methods: Fourteen epoxy dies were duplicated from two Typodont acrylic teeth. Two preparation designs were used. Group (1): represented butt margin occlusal preparation. Group (2): represented occlusal preparation with chamfer finish line. Seven dies duplicated from each group. Occlusal veneer restorations were constructed from CAD/CAM system. Each occlusal veneer cemented to the corresponding die. Universal testing machine was used to measure fracture resistance values. Load to fracture for all samples was recorded in Newton.

Results: Butt joint samples (1649.84±349.53) had significantly higher fracture resistance value than chamfer samples (1273.63±232.58) (p=0.039).

Conclusion: Within the limitations of this in-vitro investigation, it might be concluded that butt margin design provides better fracture resistance values that chamfer finish line design using lithium disilicate occlusal veneers.

Keywords: different preparation design; occlusal veneer; lithium disilicate; fracture resistance.

1. B.D.S Ain-Shams University, Fixed Prosthodontics Department, Faculty of Dentistry Ain Shams University, Egypt.
2. Professor of Fixed Prosthodontics Department, Faculty of Dentistry Ain Shams University, Egypt.
3. Associate professor of Fixed Prosthodontics Department, Faculty of Dentistry Ain Shams University, Egypt.
Corresponding author: Esraa Mahmoud, email: esraamahmoud919@gmail.com

Introduction

Damage of tooth structure from the occlusal aspect of posterior teeth may be due to multiple factors including bruxism, parafunctional habits, erosion by gastric acid, diet, and traumatic injuries.(1) Unfavorable changes in esthetics, tooth sensitivity, reduced function and occlusal disharmony are all common consequences of tooth structure destruction.(2) Depending on the size and extension of the defect, treatment of erosive lesion is carried out and should be minimally invasive as possible.(3) With introduction of adhesive bonding techniques which allow using minimal invasive restorations (4), occlusal veneer restorations can be constructed to recover masticatory function rather than traditional onlays and complete coverage crowns.(5,6)

For indirect restorations, dental ceramics are the preferred restorative material because of their advantages including biocompatibility, color stability and ideal esthetics.(7) Dental ceramics are usually used for fabrication of restorations due to their success rate as well as several range of chemical and structural compositions, which have resulted from recent advances in biomaterial technology. (8) Various CAD/CAM-machinable ceramic materials have been industrialized in recent years to meet the aesthetic demands of prosthetic restorations. (9)

Nowadays, lithium disilicate glass ceramics are roughly used in prosthetic dentistry.(10) It reveals perfect esthetics and good mechanical properties, as well as great dental tissue adhesion (11) It was proved that lithium disilicate in clinical situations has a perfect survival rate in individual posterior teeth.(12)

Materials and Methods

Sample grouping:

A total number of 14 occlusal veneers were divided into 2 groups according to preparations design as follow:

- Group (1): occlusal reduction with butt joint (n=7)
- Group (2): occlusal reduction with chamfer finish line. (n=7)

Sample preparation:

Two typodont acrylic teeth of mandibular molars were selected. For each tooth, silicon indexes were created to determine the amount of occlusal reduction in mesiodistal and buccolingual direction. Anatomical occlusal reduction was set 1mm for each group.

For butt joint group: A cylindrical coarse diamond bur was used to make depth grooves on the occlusal surface. Then, removal of tooth structure between them was done.

For chamfer finish line group: the occlusal surface was prepared as for butt joint group. Chamfer finish line was prepared 1 mm below occlusoaxial line angle on the axial wall. The undercuts on the axial walls were removed with a convergence angle of 6.

Roundation and smoothness of all sharp line angles and edges was done using finishing stones and rubber cups.

Duplication of typodont teeth done using silicone duplicating material. Each mold was poured seven times with epoxy resin material.

Restoration fabrication:

- Each die was scanned with extraoral MEDIT scanner. Then, designing the restoration was done using Exocad Galway 3.0 software. Restoration thickness was set 1.2:1.5 mm at central groove, 1.6:1.7 mm at slope and 1.8: 2 mm at cusp.
- The combination (crystallization/ glaze) was conducted in a compatible ceramic furnace (P3010 Ivoclar Viva Dent furnace)

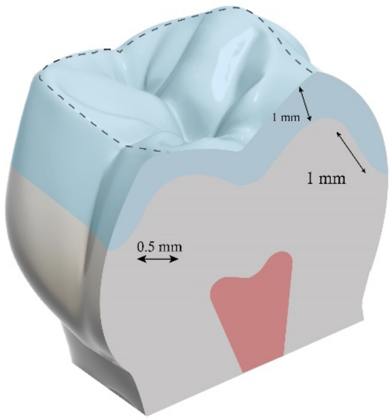
Restoration Cementation:

Restorations were etched by hydrofluoric acid (9.5%) for 20 seconds. After that restorations were rinsed carefully with water for 15 seconds and air dried. Application of silane coupling agent over the internal surface of restorations for 60s. Afterwards, dryness was done.

The outer surfaces of epoxy dies were cleaned with ultrasonic cleaner, then a thin layer of bonding agent was applied, then gentle oil-free compressed air drying and 20 seconds light curing.

Application of duel cure resin cement to fitting surface of occlusal veneer using finger pressure then subjected to a fixed load of 1kg. Each surface was cured initially for 2 seconds and the excess cement was removed using microbrush. Light curing was performed for 40 seconds on each tooth surface.

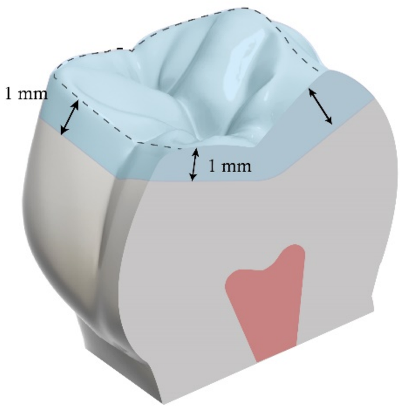
Finishing and polishing of each restoration post cementation using specifically designed ceramic polishing kit. Storage of all samples was done in distilled water for 24 hour prior to testing



chamfer finish line group

Fracture resistance test:

Samples were held to the lower fixed partition of testing machine. The fracture test was performed using a compressive mode of load applied occlusally with a metallic sphere (5.6 mm diameter) attached to the upper movable compartment of the testing machine travelling at 1mm/min cross-head speed with a tin foil sheet in-between to achieve uniform stress distribution and reduce transmission of local force peaks. The load requisite to fracture was recorded in Newton.



Butt margin group

Results

Descriptive statistics for fracture resistance (N) for different groups

Preparation design	mean	Standard deviation	median	range
Butt joint	1649.84	349.53	1517.88	759.12
Chamfer finish line	1273.63	232.58	1327.32	531.26

Preparation design (mean±SD)		p-value
Butt joint	**Chamfer**	
1649.84±349.53	1273.63±232.58	**0.039***

Significant ($p \leq 0.05$) ns; non-significant ($p>0.05$)

Effect of type of preparation design within Emax occlusal veneers:

Butt joint samples (1649.84±349.53) had significantly higher fracture resistance value than chamfer samples (1273.63±232.58) (p=0.039).

Discussion

Minimal invasive non- retentive occlusal veneers have shown success in restoring wear, lateral open bite and oral rehabilitation cases. However, there is a lot of available different preparation design, yet there is insufficient data on the optimal preparation design and its impact on fracture resistance.

This present study designed to evaluate the effect of two preparation designs upon occlusal fracture resistance.

In-vitro studies establish consistent settings in terms of impression technique, preparation design, and experimental performance, yielding more realistic assessments. Also comparing to the in vivo investigations, the in vitro results should be observed carefully due to testing restrictions that do not accurately reflect clinical circumstances. However, it may be good to provide useful hints and directions for therapeutic applications. .[13]

Typodont teeth were used in the current study to mimic the preparation of occlusal veneers clinically. Natural teeth have a lot of variance due to age, different structures, and storage duration, making standardization of the tests challenging. [14]

The benefits of using typodont teeth include the easy replica achieving the few existing variables, standardized preparation which aids in reducing as many faults and disturbing parameters as possible, and the creation of all samples in the same initial situation, allowing all manufacturing and testing procedures to be standardized.

Each prepared typodont tooth was reproduced in this study by using silicon index to produce epoxy dies. Although natural teeth provide a better approximation of clinical circumstances and bonding than dies in in vitro research, they typically have varying dimensions, structures, and storage duration following extraction, making it difficult to standardize abutment preparation.

Yucel et al.[15], reported that all ceramic restorations fracture resistance rely on elastic modulus of the chosen abutment material. Epoxy resin was proposed by Wood et al and Zahran et al. [17] to be utilized as a die material for this purpose since it reacts elastically like natural dentin, hence it was used in the current study.

Ceramic restoration clinical success appears to be influenced not just by cavity preparation schemes, but also by ceramic material chosen. Ceramic materials with better mechanical properties could perform better clinical situations.[16] IPS e.max CAD blocks were used for construction of restorations in our study.

Using lithium disilicate glass ceramic (IPS e.max CAD) in the current study because of its adhesive properties[17] and its preservation of tooth structure.[18] Due to its somewhat higher elastic modulus (100 GPa versus 84 GPa respectively) lithium disilicate can withstand severe occlusal stresses making it a reliable material for indirect restorations[19]. Additionally, the superior aesthetic properties of lithium disilicate were considered.[20]

Self-Adhesive Resin cement was used for bonding of the occlusal veneers to the dies as it decreases the need of pre-treatment of the substrates. Also, it is recommended for bonding to tooth structure as it was reported to increase their fracture resistance.[21] Because it is dual cured cement, its self-polymerization component is advantageous for the thickness of restorations that may not allow the light to pass completely through its full thickness. [22]

All specimens received a standardized tooth preparation. to mimic advanced erosion lesion of the occlusal surface.[23] The designs of the preparations were selected according to the general endorsements and preparation guidance for minimally invasive partial coverage restorations.[24] Preparation design was selected in the present investigation; (butt margin design) where only the occlusal surface was included in the preparation. This design was chosen to avoid additional tooth reduction as there is already large amount of dental tissue has been lost due to wear and erosion.[25]

Fracture resistance and flexural strength are two terms that are frequently used to describe the material strength and predict its clinical performance. Ceramic strength, on the other hand, is a complicated attribute that cannot be fully described by a single value. The maximum flexural strength differs significantly from specimen to specimen because of the flaw distribution in the material. Flexural strength of a specimen behaves more consistently when flaws are consistent and consistently distributed than when flaws are gathered randomly.

Fracture resistance might not match to respective uniaxial flexural strength of the material because mechanical behavior of the complexity of restored tooth, adhesive system and restoration can't be expected.[26] Thus, relying on fracture resistance as in in-vitro testing to the mechanical properties is more clinically relevant knowing that samples used are anatomical restorations rather than plain discs.

All specimens were tested using occlusal load by a metallic sphere to simulate natural condition when forces are applied on posterior teeth to make results more reliable.

Regarding the results of our study, mean fracture load values for glass ceramics Emax CAD butt margin group and chamfer group were (1649.84 ± 349.53 and 1273.63 ±232.58 respectively). This values were comparatively similar to a study evaluated occlusal veneer fracture resistance using different ceramic materials.[27]

Our values was relatively lower than that recorded by Andrade et al.[28], who investigated the effect of material and thickness on occlusal veneer fracture resistance, and they recorded fracture resistance for 1.5 mm thickness IPS e.max CAD (4995N) while at 0.6 mm thickness was (3067 N). Furthermore, Sasse et al.[29] reported that Emax occlusal veneers with 0.5 mm thickness at the fissures and 0.8 mm thickness at the cusps had a median fracture resistance of 2,355 N. The increased overall values of fracture resistance related to studies of Andrade et al. and Sasse et al. might be explained by adhesive luting technique with natural teeth rather than epoxy dies that enables close contact between the dental tissue, luting agent, and restoration, allowing the occlusal forces to be applied and dissipated through the tooth.[29,30]

Moreover, Guess et al. 2013 [30] reported that a 0.5 mm thickness occlusal veneers bonded to enamel had a fracture resistance comparable to occlusal veneers with 2.0 mm thickness bonded to dentin. The better fracture resistance of the ultrathin occlusal veneers is related to the greater bonding to enamel compared to bonding to dentin. On the other hand, in our study bonding was done to epoxy dies (not as strong as to natural tooth). Epoxy dies provides the advantages of test convenience and ease of standardization as previously mentioned.

Additionally, in our study anatomical occlusal veneers were used rather than flat table tops as done in other studies.[31,32] Although this anatomical design is more clinically relevant, however the change in thickness among the occlusal veneer surface together with presence of thin area as less as

(1.2mm) in central fossae might decrease the fracture resistance values in our study.

In our study, comparing two preparation design (butt margin and chamfer finish line), our results have shown that butt margin design was significantly higher than chamfer finish line (P=0.039). This might be explained by that the fact that these conventional preparations provide bulk of brittle material which is important for better distribution of compressive forces between structures with different elastic moduli. Moreover, retentive preparations as in chamfer group have more difficult geometry and moderately sharp inner boundaries, so it is more expected to find predetermined breaking points resulting in stress peaks. (33)

In addition, less values in thin chamfer group might be related to effect of the crystallization cycle of lithium disilicate margin resulting in distortion as the material shrinks. This is going well with the results of a study concluded by Gold et al that after crystallization firing, lithium disilicate CAD/CAM crowns experienced an increase in marginal gap. (34)

Limitations of this invitro study that it cannot simulate complex oral conditions and it is devoid of cyclic loading that may affect the results, so more invitro and invivo studies should be conducted to validate the reliability of our results and assess clinical performance of preparation designs.

Conclusion

Within the limitations of this in-vitro investigation, it could be concluded that butt margin design provides better fracture resistance values that chamfer finish line design using lithium disilicate occlusal veneers.

References

1. Gürpınar B, Celakil T, Baca E, Evlioğlu G. Fracture resistance of occlusal veneer and overlay CAD/CAM restorations made of polymer-infiltrated ceramic and lithium disilicate ceramic blocks. J Ege Univ Sch Dent. 2020;41(2):131–42.
2. Heck K, Paterno H, Lederer A, Litzenburger F, Hickel R, Kunzelmann K, et al. Fatigue resistance of ultrathin CAD / CAM ceramic and nanoceramic composite occlusal veneers. Dent Mater [Internet]. 2019;35(10):1370–7. Available from: https://doi.org/10.1016/j.dental.2019.07.006
3. Abdel sadek H, Al-Qatta M, Wahsh M. The Effect of Ceramic Material and Preparation Design on the Fracture Resistance of Onlay Restorations. Egypt Dent J. 2021;67(3):2509–17.
4. van Dijken JW V, Hasselrot L. A prospective 15-year evaluation of extensive dentin–enamel-bonded pressed ceramic coverages. Dent Mater. 2010;26(9):929–39.
5. Krummel A, Garling A, Sasse M, Kern M. Influence of bonding surface and bonding methods on the fracture resistance and survival rate of full-coverage occlusal veneers made from lithium disilicate ceramic after cyclic loading. Dent Mater. 2019;35(10):1351–9.
6. Xia H, Picart P, Montresor S, Guo R, Li JC, Solieman OY, et al. Mechanical behavior of CAD/CAM occlusal ceramic reconstruction assessed by digital color holography. Dent Mater. 2018;34(8):1222–34.
7. Yoon HI, Sohn PJ, Jin S, Elani H, Lee SJ. Fracture Resistance of CAD/CAM-Fabricated Lithium Disilicate MOD Inlays and Onlays with Various Cavity Preparation Designs. J Prosthodont. 2019;28(2):e524–9.
8. Denry I, Kelly JR. Emerging ceramic-based materials for dentistry. J Dent Res. 2014;93(12):1235–42.
9. Coldea A, Swain M V, Thiel N. Mechanical properties of polymer-infiltrated-ceramic-network materials. Dent Mater. 2013;29(4):419–26.
10. Allam A, Abd El-Aziz sahar, mohamed hussien. The Influence of Different Ceramics and Resin Cements on the Color Stability, Marginal Discrepancy and Fracture Resistance of Ceramic Laminate Veneers. Al-Azhar Dent J Girls. 2021;0(0):0–0.
11. Gierthmuehlen PC, Jerg A, Fischer JB, Bonfante EA, Spitznagel FA. Posterior minimally invasive full-veneers: Effect of ceramic thicknesses, bonding substrate, and preparation designs on failure-load and-mode after fatigue. J Esthet Restor Dent. 2022;
12. Al-Akhali M, Kern M, Elsayed A, Samran A, Chaar MS. Influence of thermomechanical fatigue on the fracture strength of CAD-CAM-fabricated occlusal veneers. J Prosthet Dent. 2019;121(4):644–50.
13. Gonzalo E. Comparative analysis of two measurement methods for marginal fit in metal-ceramic and zirconia posterior FPDs. Int J

Prosthodont. 2009;22(4).
14. Cameron SM, Morris WJ, Keesee SM, Barsky TB, Parker MH. The effect of preparation taper on the retention of cemented cast crowns under lateral fatigue loading. J Prosthet Dent. 2006;95(6):456–61.
15. Yucel MT, Yondem I, Aykent F, Eraslan O. Influence of the supporting die structures on the fracture strength of all-ceramic materials. Clin Oral Investig. 2012;16(4):1105–10.
16. Homsy F, Eid R, El Ghoul W, Chidiac JJ. Considerations for altering preparation designs of porcelain inlay/onlay restorations for nonvital teeth. J Prosthodont. 2015;24(6):457–62.
17. Albelasy E, Hamama HH, Tsoi JKH, Mahmoud SH. Influence of material type, thickness and storage on fracture resistance of CAD/CAM occlusal veneers. J Mech Behav Biomed Mater. 2021;119:104485.
18. Solá-Ruiz MF, Lagos-Flores E, Román-Rodriguez JL, Del Rio Highsmith J, Fons-Font A, Granell-Ruiz M. Survival rates of a lithium disilicate-based core ceramic for three-unit esthetic fixed partial dentures: a 10-year prospective study. Int J Prosthodont. 2013;26(2).
19. Fasbinder DJ, Dennison JB, Heys D, Neiva G. A clinical evaluation of chairside lithium disilicate CAD/CAM crowns. J Am Dent Assoc. 2010;141:10S-14S.
20. Yildirim B, Recen D, Tekeli Simsek A. Effect of cement color and tooth-shaded background on the final color of lithium disilicate and zirconia-reinforced lithium silicate ceramics: An in vitro study. J Esthet Restor Dent. 2021;33(2):380–6.
21. Aly MA, Mohsen C. Influence of Restoration Thickness and Auxillary Retentive Means on Fracture Resistance of Occlusal Ceramic Veneers. J Mod Res. 2021;3(2):67–70.
22. Yu H, Chen Y, Cheng H, Sawase T. Finish-line designs for ceramic crowns: a systematic review and meta-analysis. J Prosthet Dent. 2019;122(1):22–30.
23. Schlichting LH, Maia HP, Baratieri LN, Magne P. Novel-design ultra-thin CAD/CAM composite resin and ceramic occlusal veneers for the treatment of severe dental erosion. J Prosthet Dent [Internet]. 2011;105(4):217–26. Available from: http://dx.doi.org/10.1016/S0022-3913(11)60035-8
24. Ahlersa MO, Mörigb G, Blunckc U, Hajtód J, Pröbstere L, Frankenbergerf R. Guidelines for the Preparation of CAD/CAM Ceramic Inlays and Partial Crowns Richtlinien für die Präparation CAD/CAM-gefertigter Keramikinlays und-teilkronen. Int J Comput Dent. 2009;12:0.
25. Magne P, Stanley K, Schlichting LH. Modeling of ultrathin occlusal veneers. Dent Mater. 2012;28(7):777–82.
26. García-Engra G, Fernandez-Estevan L, Casas-Terrón J, Fons-Font A, Castelo-Baz P, Agustín-Panadero R, et al. Fracture Resistance of New Metal-Free Materials Used for CAD-CAM Fabrication of Partial Posterior Restorations. Medicina (B Aires). 2020;56(3):132.
27. Al-Akhali M, Chaar MS, Elsayed A, Samran A, Kern M. Fracture resistance of ceramic and polymer-based occlusal veneer restorations. J Mech Behav Biomed Mater [Internet]. 2017;74:245–50. Available from: http://dx.doi.org/10.1016/j.jmbbm.2017.06.013
28. Andrade JP, Stona D, Bittencourt HR, Borges GA, Burnett LH, Spohr AM. Effect of different computer-aided design/computer-aided manufacturing (CAD/CAM) materials and thicknesses on the fracture resistance of occlusal veneers. Oper Dent. 2018;43(5):539–48.
29. Sasse M, Krummel A, Klosa K, Kern M. Influence of restoration thickness and dental bonding surface on the fracture resistance of full-coverage occlusal veneers made from lithium disilicate ceramic. Dent Mater [Internet]. 2015;31(8):907–15. Available from: http://dx.doi.org/10.1016/j.dental.2015.04.017
30. Guess PC, Schultheis S, Wolkewitz M, Zhang Y, Strub JR. Influence of preparation design and ceramic thicknesses on fracture resistance and failure modes of premolar partial coverage restorations. J Prosthet Dent. 2013;110(4):264–73.
31. Egbert JS, Johnson AC, Tantbirojn D, Versluis A. Fracture strength of ultrathin occlusal veneer restorations made from CAD/CAM composite or hybrid ceramic materials. Oral Sci Int. 2015;12(2):53–8.
32. Baldissara P, Monaco C, Onofri E, Fonseca RG, Ciocca L. Fatigue resistance of monolithic lithium disilicate occlusal veneers: a pilot study. Odontology [Internet]. 2019;107(4):482–90. Available from: http://dx.doi.org/10.1007/s10266-019-00417-7
33. Ausiello P, Rengo S, Davidson CL, Watts DC. Stress distributions in adhesively cemented ceramic and resin-composite Class II inlay restorations: a 3D-FEA study. Dent Mater. 2004;20(9):862–72.
34. Gold SA, Ferracane JL, da Costa J. Effect of crystallization firing on marginal gap of CAD/CAM fabricated lithium disilicate crowns. J Prosthodont. 2018;27(1):63–6.