International Journal Dental and Medical Sciences Research
Volume 4, Issue 2, Mar-Apr 2022 pp 57-60 www.ijdmsrjournal.com ISSN: 2582-6018

In vitro study of fracture resistance of ceramic laminate veneers with different ceramic materials

Fatma Mohammed, MD, [1]Mahy Hassouna,MD, PhD,[2] Amal Abdelsamad Sakrana, DDS, PhD.[3]

[1]*Post-graduate student, Department of Fixed Prosthodontics, Mansoura University, Mansoura, Dkahlia, Egypt*
[2]*Assistant proffessor, Department of Fixed Prosthodontics, Mansoura Univerity, Mansoura, Dkhlia, Egypt*
[3]*Professor, Department of Fixed Prosthodontics, Mansoura Univerity, Mansoura, Dkhlia, Egypt*

Submitted: 01-03-2022 Revised:10-03-2022 Accepted: 12-03-2022

ABSTRACT

Purpose: To evaluate the fracture resistance of the laminate veneer constructedof lithium disilicate (IPS e.max CAD), zirconia reinforced lithium silicate (Celtra Duo), and ultra-translucent zirconia (Katana) cemented withresin cement.

Material and methods: Thirty prepared PMMA resin abutments were milled and used in this study.Thirty laminate veneers were milled from lithium disilicate (IPS e.max CAD), zirconia reinforced lithium silicate (Celtra Duo), and ultra-translucent zirconia (Katana) and cemented with variolinkesthetic resin cement. The specimens were subjected to thermocycling and cycling loading. The specimens were subjected to a fracture resistance test.

Results: Statistical significant difference was found infracture resistance between the IPS e.max and Celtra Duo and between the katana and Celtra Duo, while there was no statistically significant difference between the IPS e,max and katana. IPS e.max showed the highest fracture resistance(272.57±8.44) followed by katana (249.77±18.43) and the least fracture resistance was in Celtra Duo (195.34±38.22).

Conclusion: There was a non-significant difference between IPS e.max CAD and katana, while there was a significant difference between the IPS e.max CAD and Celtra Duo, and between the katana and CeltraDuo.

KEYWORDS: Laminate veneer; ceramics; fracture resistance test.

I. INTRODUCTION

Improvement of ceramic materials, adhesive system, and clinical techniques make the ceramic laminate veneers to be the first choice for minimally invasive esthetic dentistry.[1]Lithium disilicate is one of glass ceramic which is characterized by good esthetic and acceptable mechanical properties.[2]Zirconia reinforced lithium silicate material is developed by reinforcing lithium disilicate glass ceramic by addition of 20 wt% of zirconia.[3]It combines positive properties of zirconia which is superior strength and esthetic appearance of glass ceramics. Monolithic zirconia restorations have high flexural strength, require conservative tooth preparation, show accepted esthetic, low wear of the opposing tooth.[4]There are many factors affect the translucency of zirconia: structural characteristics, chemical composition, additives, sintering status, and its density.[5]Translucent zirconia strength is half of the conventional yttria-tetragonal zirconia polycrystal (with elastic modulus of 215 GPa and flexural strength of 1000 MPa).[6]

Ceramic materials are brittle and able to be fractured easily if subjected to overload or unsuitable load.[7] The most common forms of ceramic laminate veneer failure are debonding and fractures. 67% of ceramic veneer failures are related to fracture.[8]

The objective of this study was to compare the fracture resistance of lithium disilicate, zirconia reinforced lithium silicate and ultra-translucent zirconia supported by PMMA resin abutments. The null hypothesis tested was that there is an effect of ceramic materials on fracture resistance.

II. MATERIALS AND METHODS

An ivory typodont maxillary central incisor (PRO2001-UL-SP-FEM-32, NISSIN, Tokyo, Japan) was prepared to be the master abutment. Tooth preparation was performed with microdont veneer kit (Laminated veneer preparation kit REF 10.801.002, Microdont, Sao Paulo, Brazil). The tooth was prepared with Butt-joint design with incisal reduction of 1.5 mm and 0.5 mm facial reduction and extended to contain both mesial and distal contacts. Tooth was scanned by extraoral scanner (DOF, Freedom HD Dental Scanner, korea). Sixty PMMA resin abutments were milled from PMMA block (Yamahachi Dental, Japan).The resin abutments were divided randomly into 3 groups (n=10) according to type of ceramic Group E: abutments receiving IPS e.maxCAD veneer, group C: abutments receiving Celtra Duo veneer, group K: abutments receiving zirconia veneer.Extra oral scanner (Identical HybirdScaner, Medit Corp, Korea) was used to scan theunprepared andprepared resin abutment. The prepared and unprepared STL files were overlapped to each other allowing construction of laminate veneers corresponding to the original typodont tooth outline and dimensions by using Exocad chairside CAD software (version 2.2 Valetta, exocad GmbH). The restorations were milled from IPS e.max CAD block, Celtra Duo block and zirconia (Katana) disk. Milling was performed by milling machine (CORiTEC 350i Loader PRO$^+$, Imes-Icore, Germany).Milled IPS e.max CAD laminate veneers were crystallized and glazed according to manufacturer instructions while Celtra Duo laminate veneers were glazed. Milled zirconia laminate veneers were sintered in sintering furnace (Mihm-Vogt Tabeo, GmbH, Germany).Surface treatment of fitting surface of IPS e.max CAD and Celtra Duo laminate veneers was performed 9 % hydrofluoric acid for and rinsed with running water and then dried with air. Surface treatment of zirconia laminate veneer was performed by air-borne particle abrasion of fitting surface of laminate veneers with Al_2O_3. Application of silane coupling agent on fitting surface of restoration with Monobond N for 60 seconds in thin layer, then drying the remaining residue with water and oil-free air. Then surface treatment of the resin abutment was performed by 37 % phosphoric acid that was applied and distributed to the entire surface of the prepared abutmentfor 45 seconds then washed with water spray and dried softly with air spray. Application of Tetric N-Bond universal. Thebond was scrubbed into resin abutment surface for 20 seconds and then gentle air directed, then light curing for 10 seconds using a light curing unit (Bluekex LD-105, Monitex, New taipi, Taiwan). A thin layer of the cement was applied in the intaglo surface of the veneer and seating it on the abutment in inciso-cervical direction and then put the 250 g load [9]of cementation device for 60 seconds. Light curing of cement first from lingual surface for 60 seconds and 40 seconds for each surface of tooth. All the specmiens were subjected to hermal cycling (10 000 cycles in temperaturebetween 5˚C and 55˚C) to simulate one year in oral cavity.[10] The specimens were inserted on specially prepared handle to make an angle of 135˚ with long axis of the testing arm. Tin foil was inserted between the tooth and indenter to dispense the load uniformly. The indenter was blunt steel blade with 5 mm diameter was placed on the incisal edge of the laminate veneer and load application was carried out at cross head speed of 0.5 mm/min till the fracture of veneer and drop of the reading occurred.

III. STATISTICAL ANALYSIS:

Data were fed to the computer and analyzed using IBM SPSS Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp. Qualitative data were described using number and percent. Quantitative data were described using mean, standard deviation for parametric data after testing normality using Shapiro-Wilk test. Significance of the obtained results was judged at the (0.05) level.
One Way ANOVA test was used to compare the fracture resistane of the three materials.

IV. RESULTS

One way ANOVA showed that, there was a non-significant difference between the IPS e.max and katana. There was a significant difference between the IPS e.max and Celtra duo and between the Celtra duo and katana ($p < 0.001$). IPS e.max showed the highest fracture resistance followed by katana and the least fracture resistance in Celtra duo.

V. DISCUSSION

The null hypothesis tested was the ceramic material has no effect on fracture resistance was partially rejected because there wasa significant difference between the IPS e.max and Celtra Duo and between the katana and Celta Duo ($p < 0.001$).Extracted natural teeth were used in an in-vitro study to simulate the clinical situations more than resin abutment. The difficulty in standardization of dimension, age, anatomy, and storage time of natural teeth after extraction and change of elastic modulus of teeth after extraction lead to fracture of the tooth during loading. Also, the difficulty in standardization in preparation of extracted tooth lead to variation in veneer dimensions and dentin exposure which affect the bonding of the restorations.[11] In the present study, PMMA resin (Yamahachi Dental, Japan) abutments were used instead of extracted natural tooth in fracture resistance test of laminate veneer.Lithium disilicate shows good physical properties, the elastic modulus of lithium disilicate veneer is close to enamel, so it supports the enamel better than resin composites.[12]Zirconia-reinforced lithium silicate was used in this study because it is one of newly developed CAD/CAM ceramic that has high edge strength at fine edge as it contains 10% of zirconia particle so it shows good marginal fit when milled in thin thickness.[13] Translucent zirconia was introduced as a new ceramic that was an alternative esthetic solution, as it combines strength of traditional zirconia and translucency of feldspathic porcelain, so it can be used in construction of anterior and posterior crowns and veneer.[14]

Although there was a difference in elastic modulus and flexural strength of different ceramic materials, results of this current study showed that there was no significant difference between IPS e.max and katana, but there was a significant difference between the IPS e.max CADandCeltra Duo and between the katana andCeltra Duo. However, the highest fracture resistance in this study was in IPS e.max CAD group with mean fracture resistance of 272.57 ± 8.44 N followed by katana with 249.77 ± 18.43 N while Celtra Duo showed the least fracture resistance value with 195.34 ± 38.22 N. This results comes in agreement with other study by Al-Zordk et al. [15] who compared the fracture resistance of occlusal veneer constructed of lithium disilicate, ultra-translucent zirconia, and hybird ceramic, and found that after thermomechanical fatigue, there was no statisticaly significant difference in fracture resistance between three ceramic materials. In contrast the result of the current study was disagreed with Hamza et al. [16] who compared fracture resistance of lithium disilicate, zirconia-reinforced lithium silicate (vita suprinity), and bilayered zirconia substructure with veneering ceramic. It was found that the highest fracture resistance was for zirconia-lithium disilicate (vita suprinity) followed by lithium disilicate and the least fracture resistance was for bilayered zirconia. It may be attributed to the flexural strength of vita suprinity was higher than celtra duo and zirconia which was used not a monolithic restoration.

A possible explanation of decreased fracture resistance of zirconia might be the effect of color pigments of multi-layered technique. As half or more of the grains are in cubic phase which has large grain size resulting in porosity between crystals and decrease the density so it does not under goes transformation and there was no resistance to crack propagation and so decreased the mechanical properties.[17, 18]

The average masticatory force in anterior teeth was 20 to 160 N.[19] The present results provide clinically pertinent results, as the mean value of fracture strength of the three ceramic materials was higher than the average masticatory forces.

VI. CONCLUSION

Within the limitations of this in vitro study, it was concluded that fracture resistance of laminate veneer was affected by ceramic material. IPS e.max CAD has the highest fracture resistance followed by katana and the least fracture resistance was in Celtra Duo ceramic.

LIMITATIONS

The main limitation in this study was the use of resin abutment not natural tooth, and one year of thermocycling was performed only.

REFERENCES

[1]. Peumans, M; Van Meerbeek, B; Lambrechts, P and Vanherle, G. Porcelain veneers: a review of the literature. J Dent. 2000;28(3):163-77.

[2]. Magne, P and Douglas, WH. Interdental design of porcelain veneers in the presence of composite fillings: finite element analysis of composite shrinkage and thermal stresses. Int J Prosthodont. 2000;13(2):117-24.

[3]. Belli, R; Lohbauer, U; Goetz-Neunhoeffer, F and Hurle, K. Crack-healing during two-stage crystallization of biomedical lithium (di) silicate glass-ceramics. Dent Mater. 2019;35(8):1130-45.

[4]. Albashaireh, ZS; Ghazal, M and Kern, M. Two-body wear of different ceramic materials opposed to zirconia ceramic. J Prosthet Dent. 2010;104(2):105-13.

[5]. McLaren, EA; Lawson, N; Choi, J; Kang, J and Trujillo, C. New high-translucent cubic-phase–containing zirconia: Clinical and laboratory considerations and the effect of air abrasion on strength. Compend Contin Educ Dent. 2017;38(6):e13-e6.

[6]. Lan, T-H; Liu, P-H; Chou, MM and Lee, H-E. Fracture resistance of monolithic zirconia crowns with different occlusal thicknesses in implant prostheses. J Prosthet Dent. 2016;115(1):76-83.

[7]. Mörmann, WH; Stawarczyk, B; Ender, A; Sener, B; Attin, T and Mehl, A. Wear characteristics of current aesthetic dental restorative CAD/CAM materials: two-body wear, gloss retention, roughness and Martens hardness. J Mech Behav Biomed Mater. 2013;20:113-25.

[8]. Jankar, AS; Kale, Y; Kangane, S; Ambekar, A; Sinha, M and Chaware, S. Comparative evaluation of fracture resistance of Ceramic Veneer with three different incisal design preparations-An In-vitro Study. J Int Oral Health. 2014;6(1):48-54.

[9]. Aboushelib, MN; Elmahy, WA and Ghazy,

MHJJod. Internal adaptation, marginal accuracy and microleakage of a pressable versus a machinable ceramic laminate veneers. J Dent 2012;40(8):670-7.

[10]. Peumans, M; Hikita, K; De Munck, J; Van Landuyt, K; Poitevin, A; Lambrechts, P, et al. Bond durability of composite luting agents to ceramic when exposed to long-term thermocycling. Oper Dent. 2007;32(4):372-9.

[11]. Stappert, CFJ; Ozden, U; Gerds, T and Strub, JR. Longevity and failure load of ceramic veneers with different preparation designs after exposure to masticatory simulation. J Prosthet Dent. 2005;94(2):132-9.

[12]. Yamanel, K; Caglar, A; Gülsahi, K and Ozden, UA. Effects of different ceramic and composite materials on stress distribution in inlay and onlay cavities: 3-D finite element analysis. Dent Mater J. 2009;28(6):661-70.

[13]. Traini, T; Sinjari, B; Pascetta, R; Serafini, N; Perfetti, G; Trisi, P, et al. The zirconia-reinforced lithium silicate ceramic: lights and shadows of a new material. Dent Mater J. 2016;35(5):748-55.

[14]. Thompson, JY; Stoner, BR; Piascik, JR and Smith, R. Adhesion/cementation to zirconia and other non-silicate ceramics: where are we now? Dent Mater. 2011;27(1):71-82.

[15]. Al-Zordk, W; Saudi, A; Abdelkader, A; Taher, M and Ghazy, M. Fracture Resistance and Failure Mode of Mandibular Molar Restored by Occlusal Veneer: Effect of Material Type and Dental Bonding Surface. Materials (Basel). 2021;14(21):6476.

[16]. Hamza, TA and Sherif, RM. Fracture Resistance of Monolithic Glass-Ceramics Versus Bilayered Zirconia-Based Restorations. J Prosthodont. 2019;28(1):e259-e64.

[17]. Michailova, M; Elsayed, A; Fabel, G; Edelhoff, D; Zylla, IM and Stawarczyk, B. Comparison between novel strength-gradient and color-gradient multilayered zirconia using conventional and high-speed sintering. J Mech Behav Biomed Mater. 2020;111:103977.

[18]. Elsayed, A; Meyer, G; Wille, S and Kern, M. Influence of the yttrium content on the fracture strength of monolithic zirconia crowns after artificial aging. Quintessence Int. 2019;50(5):344-8.

[19]. De Boever, JA; McCall Jr, WD; Holden, S and Ash Jr, MM. Functional occlusal forces: an investigation by telemetry. J Prosthet Dent. 1978;40(3):326-33.