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Assessment of Fracture Force of CAD-CAM-fabricated Occlusal Veneer Restorations with Different Thicknesses

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Abstract

Purpose: To evaluate the fracture force of occlusal veneer restorations using ceramic material (Lithium di-silicate) and hybrid ceramic (VITA Enamic) Computer Aided Desingn/Computer Aided Manufacturer (CAD/CAM) material at different thicknesses after thermocycling.

Material and method. Thirty CAD/CAM occlusal veneer restorations were fabricated from group E (IPS e.max CAD), V (VITA Enamic) and divided into subgroups according to thickness 0.3, 0.6, 1 mm. The occlusal veneers were luted to epoxy dies (n=5). The specimens were subjected to thermocycling test then they were subjected to load until fracture using a computer controlled materials testing machine. Data were tabulated and statistically analyzed using Two-ways analysis of variance (ANOVA).

Results: There was no significant difference in the fracture force between the two materials regardless the thickness. The fracture force increases with the increase of the thickness.

Conclusion: VITA Enamic hybrid ceramic material is closer to IPS e.max CAD ceramic material in the fracture force. With the increase of thickness, it leads to increase of fracture force.

Clinical Implication: Within the limitation of this in-vitro study, hybrid ceramic (VITA ENAMIC) and IPS e.max CAD are clinically applicable as occlusal veneer restoration with thickness 0.6 mm and more.

Keywords: *Hybrid ceramics, Fracture force, CAD/CAM.*

Introduction

Ceramics are the materials of choice as long term functional indirect restorations, due to their properties esthetic, biocompatibility and high strength. Nowadays dental technologies such as CAD/CAM are in continuous evolution offering both, the dentist and the patient. All ceramic restorations are cemented by using resin cement as they provide low solubility and they have high bond strength and better esthetic. Due to high bond strength of resin to tooth structure and complicated bonding between ceramic and tooth structure, resin was added to ceramic material to make a new compound structure called hybrid ceramics. Resin bonding is required for clinical success of indirect restorations at long time. With the use of CAD/CAM indirect restorations, there is a need for successful bonding for new hybrid ceramic materials.[16] All ceramic materials are superior to composite in its physical and mechanical properties. The hypothesis of this study, that there is a significant difference between all ceramic and hybrid ceramic occlusal veneer restorations; the fracture force of all ceramic is better than hybrid ceramic.

Materials and Method

The materials were used are: IPS e.max CAD ceramic blocks; low translucency, shade A2 and size C14 (Ivoclar Vivadent/Italy), VITA ENAMIC Innovative ceramic blocks; low translucency, shade 2M2 and size C14 (VITA Zahnfabrik spitalgasse3 D-79713 Bad Säckingen Germany),and RelyX™ Ultimate adhesive dual cured resin cement (3MESPE, Seefled, Germany).

Sample Size Calculation for fracture force test: A sample size of 15 samples in each group was determined to provide 80% power for independent samples T test at the level of 0.05 significance using G Power 3.19.2

software. So we made our study on 15 samples for each material (5 samples for each thickness). (Figure 1)

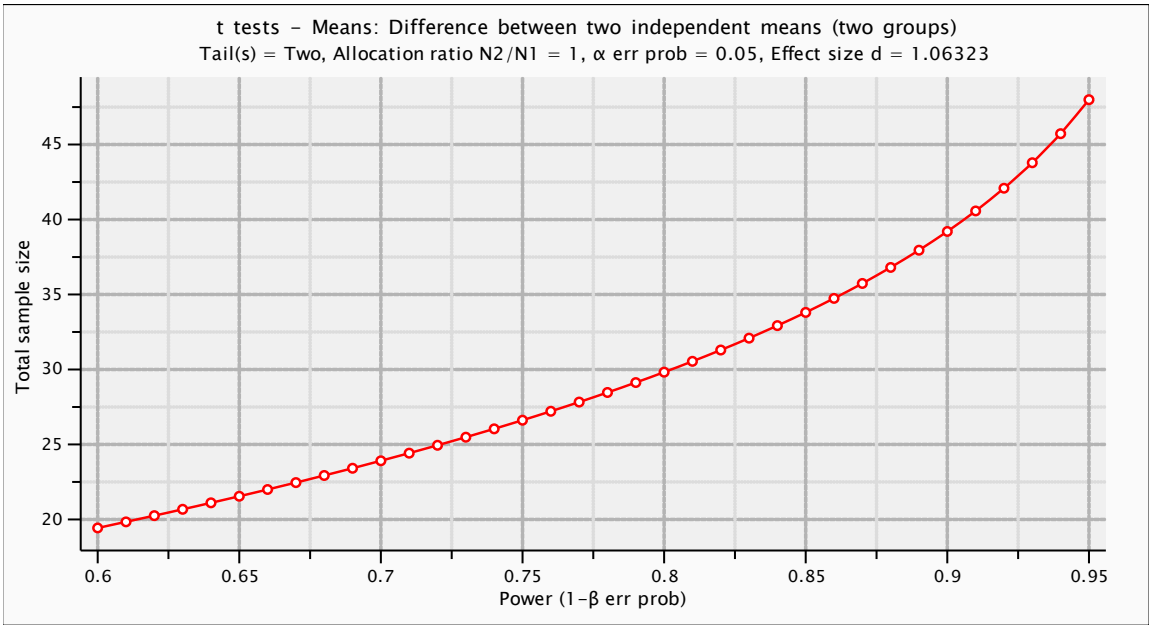

Figure (1)

Maxillary molar teeth with occlusal dimension average size (6mm x 5mm) were collected from the outpatient clinics of faculty of Dentistry Minia University. Teeth were freshly extracted, free from caries, restorations and fracture. The teeth were ultrasonically cleaned (Coltene Whaledent, Biosonic UC50 Ultrasonic, USA)of any surface debris then they were ready for use for samples construction.

Proper powder/liquid ratio of self-curing acrylic resin (cold cure acrylic resin, Acrostone, Egypt) was mixed according to the manufacturer's instructions. As it reached the dough stage, it was poured into customade split Teflon mold with (2.5cm diameter x 2.5cm height). The roots of the tooth were inserted into the center of the mold till 2 mm apical to the cement enamel junction. With the use of customade paralleling device (Egypt), to centralize the tooth in the mold. The excess of the acrylic resin was rapidly removed with metallic wax carver (Miltex. Stainless steel. pakistan**).** After complete polymerization of acrylic resin, the split Teflon mold was removed. The samples were subjected to uniform occlusal reduction with diamond cutting tools (Komet Dental. Gabr. B raseler GmbH & Co.KG Trophagener Weg 25.32657 Lemgo. Germany.) to produce a uniform preparation. Before preparation, condensation silicone rubber base (Speedix putty Ivoclar Vivadent, Liechtenstein) indices were made for tooth to aid in standardization of preparation thickness Silicone indices made by hand mixing of putty paste with catalyst according to manufacturer's instructions and loaded into a custom made metallic perforated tray. After impression setting, the index was removed[12].

The molar teeth were prepared manually using diamond cutting stones size 14 with high speed handpiece (W & H Dental Work, Burmoos, Austria) under water cooling. The occlusal surface reduction was 0.3 & 0.6 & 1.0 mm at the central fossa[19].

The preparations resulted were flat occlusal reduction without finish line (butt joint preparation). The three different preparation thicknesses were checked using a digital caliper (Miltex, stainless steel, Pakistan) with the silicon guide on the preparation**.**Epoxy resin dies construction; by the use of custom made perforated tray that has an internal diameter of 20 mm and 25 mm height[24].

Thirty impressions of prepared teeth were made using condensation silicone rubber base impression material (Speedix, Ivoclar VivaDent, Liechtenstein) by hand mixing according to manufacturer's instrucitons. The impression was loaded into the tray, prepared tooth was embedded in the impression and after setting the tooth was removed. The impression was poured by epoxy resin (kemapoxy 150, CMB, Egypt). The method

was repeated to create sixty epoxy dies. One size of epoxy paste and 1.5 size of activator were mixed under vibration (Vibromaster Bego Bremer, GmBA, Germany) for two minutes then it was leaved ten minutes before pouring to become homogenous mixture. The mixture was poured into the impression and leaved to set for 48 hours in order to reach complete setting and dimensional stability. The dies were removed from impressions, then was finished by low speed straight hand piece (Sirona Dental systems GmbH Fabrikstra Be 31 64625 Benesheim Germany)and polished by pumice (Dental Lab Pumice, Dentsply, USA) with smooth electronic brush (Miltex. Stainless steel. Pakistan).

Occlusal surfaces were surface roughened by low speed wheel stone (Komet Dental. Gabr. B raseler GmbH & Co.KG Trophagener Weg 25.32657 Lemgo. Germany) and it was ready for occlusal veneers construction (figure2).

Figure (2): Epoxy die

Designing, milling and crystallization of occlusal veneers;all occlusal veneers (IPS e.max CAD & VITA ENAMIC) were fabricated according to the direction of manufacturing companies for each fabrication system. Epoxy dies were scanned sequentially with camera system without powder (Cerec Omnicam 4.4.4 by Dentsply Sirona).Designing of all occlusal veneers were carried out using a standard protocol, on the computer software.

The thickness of occlusal veneers was 0.3 mm, 0.6 mm and 1.0 mm.

The integrity of the structure was visually checked before crystallization. The IPS e.max ceramic occlusal veneers were placed into the oven (programat P310 by ivoclar vivadent) for crystallization. At the end, the veneers were removed from the oven when it reached at room temperature. (Figure 3)

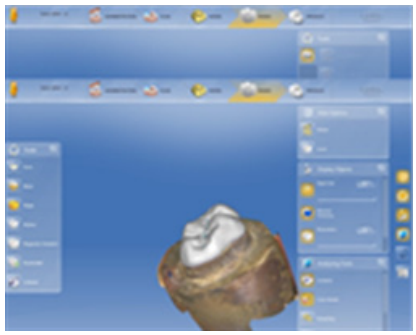

Figure (3) Visual veneer in position

Cementation of the occlusal veneers to the corresponding epoxy resin dies; occlusal veneers were etched using hydrofluoric acid gel 9.5% (*BISCO-Schaumburg U.S.A*) for 60 seconds, for VITA ENAMIC and 90 seconds, for IPS e.max CAD according to manufacturer instructions. After etching, the veneers were washed with water and dried using air spray (dental chair Roson. China). Then, veneers were brushed by silane coupling agent (BISCO-Schaumburg U.S.A) and wait for 30 seconds then it was dried with air syringe according to manufacturer instructions. Epoxy dies were left clean dry; bonding agent (Adper Single Bond 3M ESPE U.S.A) was brushed to the epoxy dies and light cured (Denjoy, China) for 20 seconds.

RelyX-Ultimate dual cured resin cement clicker was used. One click applied on the veneer and applied on the die and loaded by the loading device 6 N load [9]

Under load, the excess was removed then curing of the samples for 40 seconds.

After complete cementation of all occlusal veneers, the samples were ready for the tests. (Figure 4)

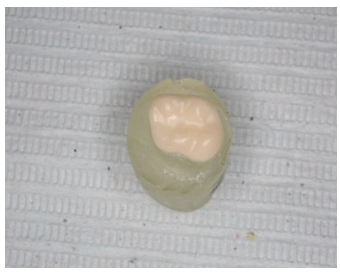

Figure (4) sample after cementation

Thermocycling procedures :- In this study the number of cycles used was 1000 cycles representing nearly 2years clinically. Dwell times were 25s in each water bath (Robota automated thermal cycle; BILGE, Turkey) with a lag time 10s. The low-temperature point was 5°C. The high temperature point was 55°C.

Fracture Force Test: According to manufacturer instructions,samples were secured to the lower fixed compartment of testing machine by tightening screws. Fracture test was done by compressive mode of load applied occlusally using a metallic rod with spherical tip (5.6 mm diameter) attached to the upper movable compartment of testing machine (Model 3345; Instron Industrial Product, Norwood, MA, USA) travelling at cross-head speed of 1mm/min. 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.

Results

There was no significant difference in the fracture force between the two materials regardless the thickness. There was significant diffirence between different thicknesses regardless the material type. There was no significant difference between the two materials at thickness of 0.3mm. In the group with 0.6 and 1mm mm thicknesses, there was a significant difference and IPSe.max CAD had higher strength than VITA Enamic. The fracture strength increases with the increase of the thickness in both materials.

1. Fracture force measurement:

Table 1: Effect of material, thickness and interaction between both on Fracture force

Fracture Force	F	P Value
Material	12.89	0.001*
Thickness	92.98	<0.001*
Material * Thickness	1.49	0.245

Two-ways-ANOVA test, *: Significant level at P value < 0.05

Table 2: Comparison of fracture force between the two materials regardless the thickness

		Material		P value
		E-max	Vita Enamic	
		N=15	N=15	
Fracture force	Range	(632.5-2310)	(547.3-1723)	0.272
	Mean ± SD	1329.5±552.9	1096.5±418.3	
	Median	1292.5	1049	

Mann Whitney test for non-parametric quantitative data (expressed as median) between the two groups, Significant level at P value < 0.05

Table 3: Comparison of fracture force between the different thicknesses regardless the Material type

		Thickness			P value
		0.3 mm	0.6 mm	1 mm	
		N=10	N=10	N=10	
Fracture force	Range	(547.3-846)c	(820-1393.8)b	(1410-2310)a	<0.001*
	Mean ± SD	706.5±93.3	1147.8±188.1	1784.8±309.7	

One-way ANOVA test for parametric quantitative data between the three groups followed by post hoc analysis between each two groups, Superscripts with different small letters refer to a significant difference between each two groups, *: Significant level at P value < 0.05

Discussion

Egbert J S, et al (2015) stated that in case of patient with severly worn dentition, CAD/CAM occlusal veneer restoration made of hybrid ceramic is an alternative to full coverage restorations. The failure load of teeth restored with full coverage with 1.5- 2.00 mm was to be 771-1183 N[3], that is lower than this study (1727-2415). This fracture strength was reported to be higher than human masticatory forces (585-880) **Kikuchi M et al, 1997.**

In accordance to **Chen C, et al (2014)**reported that with increase the thickness of IPS e.max CAD, the fracture resistance increased. There is no change between 0.5 mm and 1.5 mm thickness but sharp increase occurred at

2.0 mm. Tha normal occlusal load is 100 N-200 N in the molar area and 965 in accidental bite. 1000 N is required for clinical longivety. This requirement was achieved in the test specimens of Chen et al, 2014 and also at 0.5 mmor 1.0 mm thickness.(4 & 5 & 6).

Stawarczyk B et al (2016)reported that the fatigue resistance of occlusal veneers was increased by CAD/CAM composite in comparison with lithium disilicate ceramics (schlichting et al., 2011). Results of their study (stawarczyk) CAD/CAM revealed higher flexural strength than VITA Enamic, but lower than lithium disilicte ceramic.

Hamburger J T, et al (2014): Using a total-etch adhesive system improved the resistance to fracture(7). Normal occlusal forces are 50-300 N and reaches to 1200 N in case of clenching(8). E.max CAD showed minimal occlusal thickness 1.5 mm. In the study of **Hamburger J T, et al;** Direct composite restorations give good properties at high occlusal load.

The hypothesis of this study was partially rejected that there was no significant difference between IPS e.max and VITA Enamic materials in fracture force test but there was a significant difference between the two materials at 0.6 mm thickness.

Conclusion

Within the limitation of this study:

1. IPS e.max CAD and VITA Enamic are clinically applicable for occlusal veneer restorations and they are closer to each other in the fracture force.
2. Thickness has great effect on the restoration force, as with increase of the thickness the force increases.
3. Thin thickness as 0.3 has questionable survival in the oral environment. In case of patients with bruxism, it is advised to use restoration thickness not less than 0.5 mm.
4. Occlusal veneer restorations are advised to be used as a conservative approach and accepted force.

References

1. Martin R, Tobias P, Carola K, Michael B and Gerhard H. The in vitro fracture force and marginal adaptation of ceramic crowns fixed on natural and artificial teeth. J Prosthodontics (2000);p387-391.5p.
2. 68. Rosenstiel S F, land M F and Fujimoto J. Contemporary fixed Prosthodontics. 3rd ed., Mosby, St Louis, USA, 2001.
3. Pallis K, Griggs J A, Woody RD. Fracture resistance of three all-ceramic restorative sysyems for posterior applications. J Prosthet Dent 2004;91:561-9.)
4. Thompson V P, Rekow D E. Dental ceramics and the molar crown testing ground. Journal of Applied Oral Science: Revista FOB 2004;12:26-36.
5. Kurtoglu C, Uysal H, Mamedov A. Influence of layer thickness on stress distribution in ceramic-cement dentin multilayer system. Dental Materials Journal 2008;27:626-32.
6. Ohlmann B, Gruber R, Eickemeyer G, Rammelsberg P. optimizing preparation design for metal-free composite resin crowns. Journal of Prosthetic Dentistry 2008;100:211-9.
7. Al-Wahadni A,David J H, Grey N and Hatamleh M. The fracture resistance of Aluminium Oxide and Lithium Disilicate-based crowns using different luting cements: An in vitro Study. J Contemp Dent Pract 2009 March; (10)2:051-058.
8. Magne P, Schlichting L H, Pires H M and Narciso L B. In vitro fatigue resistance of CAD/CAM composite resin and ceramic posterior occlusal veneers. J Prosthet Dent 2010;104:149-157.
9. Henrique L S, Pires H M, Narciso LB, Magne P. Novel-design Ultra-thin CAD/CAM composite resin and ceramic occlusal veneers for the treatment of severe dental erosion. J Prosthet Dent 2011;105:217-226.
10. Davidowitz G and Kotick P G. The use of CAD/CAM in Dentistry. Dent Clin N Am 55 (2011) 559–570.
11. He H L and Swain M. A novel polymer infiltrated ceramic dental material. Dental materials 27 (2011) 527-534.
12. (Korkut L, Cotret H S, Kurtulmus H. Marginal, internal fit and microleakage of zirconia infrastructures: An in-vitro study. Oper Dent 2011; 36:72-79.)
13. Sorrentino R., De Simone G. and Tetè S. “Five-year prospective clinical study of posterior three-unit zirconia-based fixed dental prostheses” Clin Oral Invest.2012; 16:977–985.)
14. Coldea A, Swain V M and Thiel N. Mechanical properties of polymer-infiltrated-ceramic-network. Dental Materials 29 (2013) 419-426.

15. Kurbad A and Kurbad S. Anew, hybrid material for minimally invasive restorations in clinical use. International Journal of computerized Dentistry Jan 2013, 16 (1):69-79.
16. Spitznagel A F, Horvath D S, GUESS C P and Blatz B M. Resin bond to indirect composite and new ceramic/polymer materials: A review of the literature. (J Esthet Dent 26:382-393. 2014).
17. Ruse N D and Sadoun M J. Resin-composie blocks for dental CAD/CAM applications. J Dent Res 2014.
18. Hamburger J T, Opdam N J, Bronkhorst E M and Huysmans M C. Indirect restorations for severe tooth wear: fracture risk and layer thickness. J of Dentistry 42 (2014) 413-418.
19. Johnson A C, Versluis A, Tantbirojn D and Ahuja S.The fracture strength of CAD/CAM composite and composite-ceramic occlusal veneers. J of Prosthodontic research 58 (2014) 107-114.
20. Ruse N D and Sadoun M J. Resin-composie blocks for dental CAD/CAM applications. J Dent Res 2014.
21. Della A B, Corazza P H and Zhang Y. Characterization of a polymer-infiltrated ceramic-network material. Dental Materials 30 (2014) 564-569.
22. (Baciu S., Burde A., Grecu A. "Particularities of laboratory procedures for obtaining an aesthetic overlay with Cerec technology" Inter J Medical Dent.2014;4:313-317.)
23. Awada A and Nathanson D. Mechanical properties of resin-ceramic CAD/CAM restorative materials. J Prosthet Dent 2015;114:587-593.
24. Stawarczyk B, Liebermann A, Eichberger M and Guth J. Evaluation of mechanical and optical behavior of current esthetic dental restorative CAD/CAM composite. J of the mechanical behavior of biomedical materials 55 (2016) 1-11.