AL-AZHAR
Dental Journal
For Girls

The Official Publication of The Faculty of Dental Medicine For Girls, Al-Azhar University Cairo, Egypt.

Print ISSN 2537-0308 • Online ISSN 2537-0316

ADJ-for Girls, Vol. 7, No. 2, April (2020) — PP. 171:178

Effect of Material Type and Thickness on Fatigue Resistance of Posterior Bonded Occlusal Veneers

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http://adjg.journals.ekb.eg

DOI: 10.21608/adjg.2020.7842.1111

Restorative Dentistry
(Removable Prosthodontics, Fixed Prosthodontics, Endodontics, Dental Biomaterials, Operative Dentistry)

ABSTRACT

Purpose: The purpose of the current study was to evaluate the fatigue resistance of zirconia reinforced lithium silicate (VS) and hybrid ceramic (VE) occlusal veneers, with two different thicknesses.

Materials and Methods: twenty extracted human maxillary first molars were prepared to replicate worn occlusal table. Samples were distributed into two groups according to the received occlusal veneers material; Vita Suprinity and Vita Enamic, each group was further subdivided into two subgroups according to the thickness of the occlusal veneers (0.6mm or 1.2mm). The samples were cemented by self-adhesive resin cement. Samples were subjected to step fatigue resistance test, Assessment of fracture mode was evaluated.

Results: The higher mean fatigue resistance values were recorded in Vita Suprinity compared to Vita Enamic occlusal veneers. The higher mean fatigue resistance values were recorded in 1.2 mm compared with 0.6 mm thickness. The mean fatigue resistance value was non –significant at the interaction of groups and subgroups variables.

Conclusions: Thin (1.2mm) and ultra-thin (0.6mm) Vita Suprinity and Vita Enamic can be used to construct occlusal veneers in terms of fatigue resistance values.

KEYWORDS

Fatigue Resistance, Occlusal Veneers, Thickness

INTRODUCTION

Wear of the occlusal surface of teeth is a ordinary procedure through life. But, increased tooth wear of occlusal surface can result in pulp diseases, improper occlusion, compromised function, and unpleasant esthetic [(1)]. The etiology of tooth wear is multifactorial and related to diet habits, medical diseases, and habits that lead to attrition of the enamel and dentine [(2)].

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Treatment of teeth wear should be by treatment of the reason and preventing of further decay, the restorative stage depends on the degree of damage. Early abrasions need just follow-up, dentin sealing using a bonding agent, or composite restorations. On the other hand, restoring excessive wear lesions by extra adhesive methods, permitting least reduction of tooth "no preparation" would be the best alternative [3] .

Occlusal veneers are a modern restorative option for teeth with occlusal wear. They aim to improve occlusal vertical dimension for excessive occlusal wear cases which may be associated with a parafunctional habits or progressive physiological processes. The main advantage of occlusal veneers is the regaining of the mastication with great conservation of dental structure as it is a conservative option compared to onlays and full coverage crowns[4]. The usual recommendation thickness of ceramic restoration is 1.5 to 2.0 mm to have the desired ethetic and durability[4], but their use in thin preparations depending on their construction options and mechanical properties. Many solutions for technical challenges during fabrication of the restoration can be solved by using the dental CAD/CAM systems. Moreover, the perceptions of CAD/CAM dentistry and conservation of tooth preparation are promising[5].

New glass ceramic (Vita Suprinity), with the assistance of an advanced manufacturing technique , the glass ceramic is enhanced with zirconia (approximately 10% by weight). Moreover, all the crystalline components are relatively small (approximately 0.5μm) so that only a limited amount of light refraction is possible, the result is a zirconia reinforced lithium silicate ceramic (ZLS). This glass ceramic has a special fine-grained and uniform structure which forms a material with good quality and stable at high load capacity, and reliability [6, 7].

On the other hand, new ceramic hybrid materials have been introduced with a dual network structure (Vita Enamic). In this dental material, the main fine-structure ceramic network (86% by wt.) is reinforced by a polymer network, with both networks fully combined. It has the positive characteristics of ceramics and composite. This material ensures exceptional stability between strength and elasticity and offers great absorption of masticatory forces [8] .

The purpose of this study was to evaluate the fatigue resistance of zirconia reinforced lithium silicate (Vita Suprinity) and hybrid ceramic (Vita Enamic) occlusal veneers, with two different thicknesses (1.2mm and 0.6mm). The null hypothesis of this study was that there could be no difference in fatigue resistance of occlusal veneers constructed in two thicknesses (0.6 and 1.2 mm) using Vita Suprinity glass ceramic and Vita Enamic hybrid ceramic.

MATERIALS AND METHODS

At the present study, 20 freshly extracted human maxillary first molars of comparable dimensions, were selected in accordance with guidelines from research ethics committee approval of Faculty of Dental Medicine,Al-Azhar University, Selected molars had similar dimensions measured using a digital caliper. The teeth were cleaned from any calculus deposits and debris by using an ultrasonic scaler and were examined for any cracks.

Selected molars were embedded in epoxy resin blocks using plastic rings as molds. Molars were vertically centralized up to 2mm below CEJ in the plastic ring during construction of the epoxy resin blocks by using dental surveyor.

Selected molars (N=20) were haphazardly divided into two main groups according to the ceramic material used for construction of occlusal veneers as follows; Group (S): molars received Vita Suprinity occlusal veneers, Group (E): molars received Vita Enamic occlusal veneers. Each group was further subdivided according to the thickness of the constructed occlusal veneer into two subgroups as follows; Subgroup (T): molars received thin occlusal veneers with 1.2 mm thickness. Subgroup (U): molars received ultrathin occlusal veneers with 0.6mm thickness.

All teeth was prepared to a flat occlusal surface configuration using a microsaw (Isomet 4000, Buehler,USA). The preparation was done 4mm occlusal to the cemento-enamel junction measured at the maximum convexity of cervical line at the mid mesial surface using a digital caliper. Two rounded shallow depressions (1mm in diameter) were prepared on the occlusal surface of every prepared tooth using a medium sized round bur, 2mm from the mid-mesial and mid-distal external surfaces of each tooth to aid in seating of occlusal veneers and prevent rotation of the restoration during cementation.

Fabrication of occlusal veneers:

All occlusal veneers were fabricated using CEREC AC CAD/CAM milling machine. A bio-generic individual design was selected to allow designing the restoration from the software database so that all occlusal veneers would have the same anatomy dimensions. Prepared teeth were scanned using Omnicam camera.

The restoration parameters were fixed for all restorations for standardization. The two investigated thicknesses of the restoration (0.6 mm and 1.2 mm) were measured from the depth of central fossa to the preparation surface.

Occlusal veneers were then milled following the prepared design after adjusting the milling position of the restoration in the block using Vita Suprinity and Vita Enamic blocks. According to manufacturers' instructions Vita Suprinity occlusal veneers were subjected to crystallization process in the programat P510.

Cementation of occlusal veneers

Occlusal veneers were cemented using TotalCem self-adhesive resin cement to their respective prepared molars. The prepared teeth were etched with 34% phosphoric acid for 30 seconds for enamel only according to the manufacturer instructions, followed by rinsing and drying.

Occlusal veneers were etched following their respective manufacturer's recommendations, by etching with 8% hydrofluoric acid applied for 20 seconds on Vita Suprinity restorations, and 60 seconds for Vita Enamic restorations, followed by rinsing and drying. Silane bonding agent was brushed on the etched ceramic surfaces of all samples and left for 1 min then dried according to the manufacturer's instructions.

TotalCem resin cement was painted on the intaglios surfaces of the veneers. All samples were placed under 3kg weight and then light cured. After cementation samples of each group was kept in an incubator at 37^{O}C for 24 hours before testing.

Fatigue resistance testing:

Fatigue resistance test was conducted for all samples via the step-test method using a computerized materials testing machine by applying compressive load occlusally using a metallic rod with spherical end (5.6 mm) attached with the upper mobile compartment of the testing machine moving at cross-head speed of 0.5 mm/sec. Each sample was subjected to a suggested number of cycles with a sequential increasing in stress levels, till failure of the sample.

A cyclic load was applied in the present study at a 1.6 Hz. frequency and 5,000 cycles at each load step. If the sample survived the 5,000 cycles, the load was increased by a fixed load increment (100 N) in same sample. The number of cycles related to the fracture of the samples was recorded. The maximum fatigue load (LE) maintained by every sample was calculated in accordance with Nicholas equation [9].

After fatigue testing, samples were examined using a magnification lens and the modes of failure were classified as follows: Type I: fracture of restoration only, Type II: fracture of the restoration and enamel and Type III: fracture of the restoration, enamel, and dentin (Catastrophic fracture).

Statistical analysis:

Statistical analysis was then done by software program SPSS 19 to compare between both groups and subgroups. As data showed a normal distribution, Independent t-test was used for 2 group's comparisons.

RESULTS

1. Statistical analysis of fatigue resistance values:

A. Effect of material:

Within subgroup (T) (occlusal veneers with 1.2 mm thickness), the higher mean value was recorded in group (S) (Vita Suprinity occlusal veneers). Independent t test showed non-significant difference (p=0.42). (Table 1)

Within subgroup (U) (occlusal veneers with 0.6 mm thickness), the higher mean value was recorded in group (S) (Vita Suprinity occlusal veneers). Independent t test showed non-significant difference (p=0.40). (Table 1)

B. Effect of thickness:

In group (S) (Vita Suprinity occlusal veneers), the higher mean value was recorded in subgroup (T) (Vita Suprinity 1.2mm thickness) compared with subgroup (U) (Vita Suprinity 0.6mm thickness). Independent t test showed that this difference was statistically non-significant (p=0.129). (Table 2)

In group (E) (Vita Enamic occlusal veneers), the higher mean value was recorded in subgroup (T) (Vita Enamic with 1.2 mm thickness) compared with subgroup (U) (Vita Enamic with 0.6mm thickness).

Independent t test showed that this difference was statistically non-significant (p=0.051). (Table 2)

Comparison of fatigue resistance values (N) of all studied subgroups:

The highest mean fatigue resistance value was recorded in subgroup (ST) (Vita Suprinity 1.2mm), while the lowest men value was recorded in subgroup (EU) (Vita Enamic 0.6mm). ANOVA test revealed that the difference was statistically non-significant (p=0.063). (Table 3)

2. Fracture mode assessment:

All ultrathin occlusal veneers samples, subgroup (U) showed type III failure (Catastrophic fracture with fracture of restoration, enamel and dentin). Meanwhile, thin occlusal veneers samples subgroup (T) showed different types of fracture depending on the material. Vita Suprinity occlusal veneers, group (S) showed type I and type III failure, while Vita Enamic occlusal veneers, group (E) showed the three types of failure being distributed among samples.

Table (1): *Comparison of mean fatigue resistance (N) value between the same subgroups (Independent t test)*

	Subgroup T		Subgroup U	
	ST	**ET**	**SU**	**EU**
Mean	1262.57	1211.98	1150.28	1100.01
SD	104.06	83.32	105.79	70.71
Mean difference	50.59		50.27	
Std error of difference	59.62		56.91	
T	0.85		0.88	
P	0.42ns		0.40ns	

Significance level P<0.05, ns=non-significant

Table (2): *Comparison of mean fatigue resistance values (N) within the same group (Independent t test)*

	Group S		Group E	
	ST	**SU**	**ET**	**EU**
Mean	1262.57	1150.28	1211.98	1100.01
SD	104.06	105.79	83.32	70.71
Mean difference	112.29		111.97	
Std error of difference	66.36		48.87	
T	1.69		2.29	
P	0.129ns		0.051ns	

Significance level P<0.05, ns=non-significant

Table (3): *Comparison of mean value of fatigue resistance in different subgroups (ANOVA test)*

Subgroups	Mean	Std. Dev	Std. Error	95% Confidence Interval for Mean		Min	Max	F	P
				Lower Bound	Upper Bound				
ET	1211.98	83.32	37.26	1108.53	1315.44	1097.86	1333.20	2.97	0.063ns
ST	1262.57	104.06	46.54	1133.37	1391.78	1100.14	1387.04		
EU	1100.01	70.71	31.62	1012.21	1187.81	1000.02	1200.02		
SU	1150.28	105.79	47.31	1018.93	1281.64	1000.80	1300.02		

Significance level P<0.05, ns=non-significant

DISCUSSION

Conservation of tooth structure is important in restorative dentistry [10] .Since the preservation of tooth structure is dominant in preserving suitable balance among biologic, functional, mechanical, , and esthetics [11] . It is important to preserve pulp vitality and avoid endodontic management with the subsequent requirement for posts and cores [11,12].

As investigated in previous studies; preparations with deep chamfers and shoulders, as necessary for full coverage, were intensely related to more micro-leakage and pulpal problems [13-16].

Ultrathin occlusal veneers are a modern restoration option that proposed as a restorative treatment for teeth having occlusal wear. They are beneficial way to improve the occlusal vertical dimension of patients with excessive occlusal wear associated with parafunctional habits[2].

The construction of occlusal veneer could be done with different newly developed materials, thus to select the best material with the proper thickness that can be used as a posterior bonded occlusal veneer, it should be tested to withstand the fatigue that results during force application on the restored tooth, therefore the purpose of this study was to evaluate the consequence of the different material types and thicknesses on fatigue resistance of posterior bonded occlusal veneers

All selected molars were sectioned 4 mm occlusal to the cemento-enamel junction, vertical to the long axis of the tooth surface by micro-saw to produced flat occlusal surface preparation [17,18], instead of preparations following occlusal anatomy that keeps the cuspal inclination as constant as possible [19,4] ,or preparations with ferrule design[20] . This preparation design was selected to demonstrate the clinical situation of sever tooth wear [17].

In this study, occlusal veneers were constructed in two thicknesses; according to previous studies as thin occlusal veneers with 1.2 mm thickness and ultrathin 0.6 mm thickness were measured from the depth of central fossa [11, 21].

To simulate conditions that are close to possible clinical situation the fatigue resistance of constructed occlusal veneers was evaluated. Fatigue resistance of the restoration can be assessed by different methods, cyclic isometric loading at specific frequency using load and then followed by stepwise loading, then the number of cycles at first failure was recorded[4].

The choice of step-test method to be used in this study as it is useful fatigue test. It involves a time- changeable load test, where all samples were exposed to successively greater stress levels in preset numeral cycles [22]. The advantage is that step-test in gaining reliable info about a restorative treatment in a less time [23-25].

The null hypothesis of this study that there could be no change in fatigue resistance of occlusal constructed using Vita Suprinity and Vita Enamic in two thicknesses (0.6mm and 1.2mm) is accepted.

The obtained higher fatigue strength values for zirconia reinforced lithium silicate ceramic compared to hybrid ceramics in different studies can be explained in terms of their structure. Many factors affect the fracture resistance of all-ceramic restorations, for example microstructure and fatigue of the ceramic material, fabrication method, the last preparation design, and the cementation technique [27].

In this study there was non-significant difference in the fatigue resistance of the tested materials, The fatigue resistance of the examined materials did not match their respective flexural strength as the flexural strength of the VITA Suprinity material is 420 MPa and for the VITA Enamic 160 MPa. , that approved that the mechanical performance of the repaired tooth complex, that is restorative material, repaired tooth and adhesive system, would not be expected [28,29]. But the difference in the flexural strength could illustrate the higher levels of the VITA Suprinity material in comparison to the VITA Enamic in terms of fatigue resistance . Moreover, strong adhesive bonding with luting resin would markedly reinforce the weak ceramic restorations and balance the intrinsic strength differences between different materials [30].

Regarding the thickness of the restoration, there was no significant influence of the restorations' thicknesses on the fatigue resistance of the ceramic occlusal veneers,

These results are in confirmed with a previous study that found that different thickness of occlusal veneers did not affect their fatigue resistance. However, failure mode was affected by thickness of occlusal veneers [31].

Furthermore, a study was conducted to examine the effect of various thicknesses on the fracture strength of occlusal veneers found that no significant difference occurred among the several restorations' thicknesses regarding fracture strength [32].

However, these results are not in accordance with a study that assessed the influence of restorative material's thicknesses on the fatigue resistance. This study found that restorative material thickness has a significant effect on its fatigue resistance. Yet this study used different materials from the present study. In this study ultra-thin occlusal veneers of both composite resin materials used had higher fatigue resistance in comparison to the tested ceramics [21].

In order to have a detailed insight of the failure mechanism in each material at each thickness, the present study should have included fractographic analysis of the failed samples. This would have helped in explaining the origin site of the failure crack. Another limitation of the present study is experimenting using one type of adhesive resin cement. Including more than one cement especially those using different adhesive strategies would have thrown the light on the mechanism of strengthening the cement plays.

Also, the use of human teeth is usually associated with lack of standardization in size, shape and composition. However, every effort was taken to ensure standardization and simulation of the oral environment.

CONCLUSIONS

1. Vita Suprinity and Vita Enamic posterior bonded occlusal veneers with (0.6 and 1.2mm thickness) withstand masticatory forces in terms of their fatigue resistance.
2. Occlusal veneers constructed using Vita Suprinity and Vita Enamic are with comparable fatigue

resistance and can be used as an alternative treatment for the severely worn dentition.

3. Occlusal veneer thickness does not affect their fatigue resistance implying that with thin (1.2mm thick) and ultrathin (0.6mm thick) occlusal veneers, fatigue resistance is not critically affected.

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