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Fracture Resistance of PEEK Substructure Veneered with Different Materials for Fixed Partial Prosthesis

Hatem Talaate Mohammed Koheif ; Amany Mohamed Korsel;
Sherif Magdy El Sharkawy

Abstract
To evaluate the fracture resistance of Bio-HPP frame work veneered by different materials for fixed partial prostheses, twenty – four 3 unites bridge with PEEK substructure were on standardized PMMA abutments for premolars and molars and divided into three groups according to veneering materials. ***Group I:*** *PEEK Frame work veneered with vasoline composite.* ***Group II:*** *PEEK Frame work veneered with E-max CAD Lithium Disilicate glass.* ***Group III:*** *PEEK Frame work veneered with Hybrid ceramics. BIO-HPP/PEEK substructure veneered with vasoline composite, E-max CAD, and Vita Enamic groups (n=8). were stored in distilled water for 24 hours at 37℃, then subjected to thermocycling for 10,000 cycles (5-55ºC) with a 30-s dwell time, 20 seconds transfer time, then subjected to thermo-dynamic stressing with maximum vertical load of 5 kg with cyclic frequency of 1.7 Hz for 150,000 cycles. Samples were mounted to a universal testing machine (Instron 3365) bridges fracture resistance were tested by applying a load through a 4.2 mm diameter steel ball at a crosshead speed of 1 mm/min occlusally in the central fossa area. The maximum load causing bridge failure was recorded in newton after ageing, one-way ANOVA test show highly stastically significant difference (f=117,125, p<0.001) between different studies group as regard fracture resistance with the highest mean value was recorded for bridge fabricated from PEEK frame work veneered with vasoline composite. Bio-HPP frame work veneered with vasoline composite higher fracture resistance than the other two groups. All groups gave comparable results with standing fracture resistance forces beyond maximum masticatory biting force.*

Key words: *Frame work, CAD/CAM, Vasoline composite, E.max, VITA ENAMIC, Thermo-dynamic stressing, Fracture resistance.*

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I. Introduction

(Bio-HPP; Bredent GmbH) has been recently introduced in dentistry. Bio-HPP provides excellent biocompatibility, good mechanical behavior, high temperature resistance, and chemical stability[1, 2]. With a modulus of elasticity of approximately 4 GPa, it presents an elastic behavior comparable with bone and reduces stress on the abutment teeth and the cementation interface. Fabricated either with computer-aided design and computer-aided manufacturing (CAD-CAM) or with compression-molding, its manufacturers suggest it be used as a framework material for fixed prostheses. The high bond strength with veneering composite resin material and luting cements permits its use for resin bonded restorations[3, 4]. The composite resin veneering material in combination with the white color of the PEEK framework permits the fabrication of metal-free restorations with improved esthetic appearance compared with conventional metal ceramic RBFDPs. Additional advantages include good polishing properties, wear resistance, and low plaque affinity.

Aim of The Study
The purpose of this in vitro study was to evaluate fracture resistance of PEEK substructure veneered with different materials for fixed partial prosthesis.

II. Materials and Methods

Fabrication of Stainless-Steel Model
A stainless – steel model according to the American with two abutment dies that resembles three-unit bridge were prepared with an occluso gingival height of 3.2mm, a taper 6 degree and 4.5mm width and 1.2mm shoulder finish line all around using standardized computer numerical control machine.

Fabrication of PMMA Dies:
The stainless -steel dies were sprayed by protechno; the model was placed in Dof swing scanner optical scanner. After optical scanning of stainless-steel model, the software design (Dental DB2.2 Valleta)*
were transferred to milling machine (Arum 5x-400) (fig.1) .

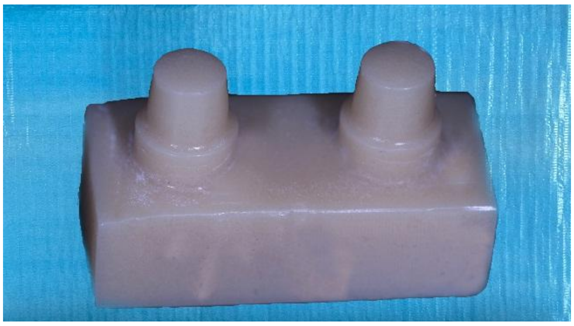


Fig.1: PMMA model

Fabrication of the Specimen
Twenty-four bridge with PEEK Substructure was fabricated and divided into three group according to veneering material.
Group I: PEEK Frame work veneered with Vasoline Composite.
Group II: PEEK Frame work veneered with IPS E-max CAD Lithium Disilicate glass.
Group III: PEEK Frame work veneered with Vita Enamic.
Construction of FDPs framework:
After scanning of the PMMA model in fig.4 using CAD/CAM optical scanner†(Dof swing). Three group of standardized three-unit FDPs framework were made of Bio-HPP blank using (CAD/CAM) milling machine‡.
Veneering technique
1- Bio-HPP PEEK veneered with Vasoline Composite Group I:
Standardized veneer thickness in all groups were designed (0.8mm thickness). The Vasoline Composite were built and immediately cured in the light- curing unit with wave lengths ranging from 320 to 550 nm for 90 seconds.
2- Bio-HPP PEEK veneered with IPS E-Max CAD Lithium Disilicate Group II:
After scanning and designing the IPS E-Max CAD veneer using Dental DB2.2 Valletta software then sent STL file to the EMAR ED5X milling machine to made the final veneer.[20]
3- Bio-HPP PEEK veneered with Hybrid ceramic (VITA ENAMIC) Group III:
The Vita Enamic* materials were milled according to the design as in group II.

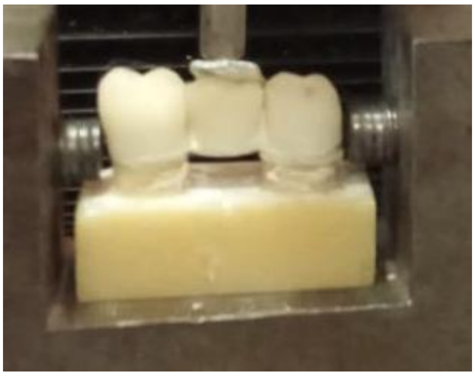
Cementation of bridge Bio-HPP framework and the veneering groups (I&II&III) on the PMMA dies
Equal amount of Paste A and B were mixed, then were applied to the fitting surface of Bio-HPP (PEEK) framework according to manufacturer`s instructions by using disposable brush. Cementation device was used in order to aid in load (3 kg) application via Instron testing machine during cementation procedure

Thermo dynamic stressing:
All samples of the three groups were subjected to thermocycling for 10,000 cycles (5-55ºC) with a 30-s dwell time, 20 seconds transfer time. This is corresponding to one year of clinical service. The thermocycled specimens were subjected to mechanical stressing in chewing simulator with maximum vertical load of 5 kg with cyclic frequency of 1.7 Hz for 150,000 cycles, which corresponds to one year of clinical service Load was applied occlusally with a custom-made load applicator [steel rod with flat tip (20x25mm) attached to the upper movable compartment of the machine [5].

Fracture Resistance Test:
All samples were individually being mounted on the universal testing machine (model 3356 Instron Instruments Ltd., USA) with a load cell of 5 k and data were recorded using computer software (Nexygen-MT; Instruments). Samples were secured to the lower fixed compartment of testing machine by tightening screws.

* version 2.2 Engine build 6654
† SHERA Werkstoff-Technologie GmbH & Co. KG Espohlstrasse Lemförde, Germany
‡ Imes-Icore GmbH Im Leibolzgraben, Eiterfeld / Germany
* VITA Zahnfabrik H. Rauter GmbH& CO. KG

Fracture test were being done by compressive static load applied occlusally at the center of the pontic with upper movable compartment of testing machine traveling at cross-head speed of 1mm/min. the load required to fracture will recoded in Newton. (fig.2)



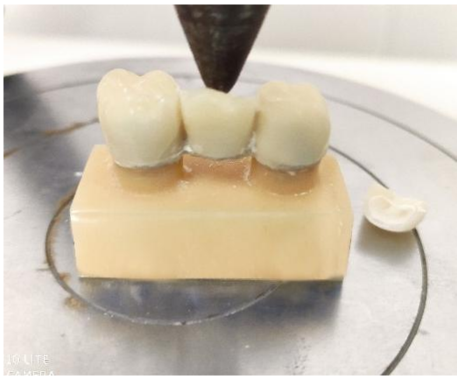


Fig 2: Fracture resistance testing Group III

III. Results

Descriptive statistics were used to describe the data using mean, standard deviation and range. One-way ANOVA test was used to show difference in Fracture Resistance between groups, which show there is a highly significant difference between the groups. Tukey's test was used to compare groups pairwise.

Table 1: Comparison between fracture resistance mean and standard deviation between the three groups:

Groups	Mean ± SD	Min--Max	F	p-value
Group I (PEEK Frame work with vasoline Composite)	2087.13±218.99	1788—2394	117.125	0.000**
Group II (PEEK Frame work with IPS E-Max CAD)	1107.75±174.44	889—1322		
Group III (PEEK Frame work with Vita Enamic)	872.50±81.53	737--955		

There is a significant difference at p-value <0.05(*), highly significant difference at p-value <0.001(**).
It was noted that Bio-HPP frame work with vasoline composite group higher fracture resistance, mean value than others groups, while the IPS E-max CAD group recorded statistically significant higher fracture resistance mean value than vita Enamic group.

IV. Discussion

This in vitro study evaluated the fracture resistance of CAD/CAM 3unit Bio-HPP FDPs framework veneered with different materials. It offer standardized and optimized conditions in the experimental performance which may not be possible to achieve in vivo.[6, 7]

The data obtained in this study supports the rejection of the null-hypothesis since the fracture resistance of different fabricated FDPs statistically different.

In this study the fracture resistance recorded for Bio- HPP (PEEK substructure veneered composite bridges group I) were the highest with a significant difference means± S.D (2087.13±218.99) compared with the other two groups.[8] These results agrees with the findings of Behr et al,[9] who reported the in vitro excellent performance of three-unit fixed restorations fabricated from PEEK veneered by different materials during investigation as it greatly exceed the fracture resistance required to withstand the normal masticatory forces (1788-2394N).[10, 11] This could be explained by the mechanical behavior of Bio-HPP /PEEK material as regard to its ideal modulus of elasticity properties that is closer to composite material and dentin that might reduce stress induction at the interface layer at different layers of the bridges.[3]

The material that exhibited the second highest value of fracture resistance was IPS E.max CAD with a mean of 889 N, these findings can be attributed to the considerable strength of the ceramic content as it is composed of 70% fine-grain lithium disilicate crystals embedded in a glassy matrix, as described by Ivoclar Vivadent. Another factor that could potentially be responsible for these findings is the bond strength between the ceramic and substructure (framework).

Vita Enamic (group III) was the least fracture resistant material with a mean of 773 N. The modes of failure in this group were relatively comparable to those of the other groups. Vita Enamic consists of two 3-dimensional interpenetrating network structures: the predominant fine-structure feldspar ceramic network (75%

by volume or 86% by weight) that is reinforced by a polymer network consisting of methacrylate polymer (14% by weight or 25% by volume) (Coldea, 2014). The increased content of the glassy phase weakens the framework by lowering the resistance to crack propagation (Alla, 2013, Sakaguchi and Powers, 2007).

IPS e.max CAD (group II) exhibited higher fracture resistance values than Vita Enamic (group II). This finding is in agreement with the results of the studies by Albero et al., Sagsoz and Yanıkoglu, Al-Akhali et al., and Sagsoz et al. Al-Akhali et al. evaluated the performance of veneered found that the IPS E.max CAD samples exhibited higher fracture resistance than the Vita Enamic samples.

V. Conclusions

Based on the results and thermo dynamic stressing:

1- Bio-HPP frame work veneered with vasoline composite group showed significant higher fracture resistance than veneered with IPS E-Max group and Vita Enamic group.

2- All groups gave comparable results with standing the fracture forces beyond the maximum masticatory biting force.

Recommendations

Based on the results:

1-Bio-HPP has proved its efficiency to be used as frame work crown and bridge.

2-further clinical evaluation of a complete resin-veneered bridge is needed to study the effect of current para meters.

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