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Original Research

Tensile bond strength of three composite veneering systems on cad/cam milled biohpp- an invitro study

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ABSTRACT:
Background: Bio high-performance polymer (BioHPP) based on polyetheretherketone (PEEK) is used as a dental framework material in prosthodontics. The use of PEEK is still difficult in the anterior aesthetic zone due to its opaque graycolor. This limitation could be overcome by layering PEEK frameworks with composite resins to achieve a better shade and translucency. So, durable bonding is essential to ensure an adequate functional outcome and long-term stability of the veneer. The purpose of the study was to evaluate the tensile bond strength of three types of composite (Shofu, Bredent, Gradia) veneered over BioHPP (PEEK). **Materials and methods**: Sixty BioHPP (PEEK) samples were fabricated and divided into three groups for veneering of composite (Shofu, Bredent, Gradia) using Ceresin Bond I & II, Visio.link and GC primer as bonding agents respectively. The tensile bond strength was evaluated using a universal testing machine. **Results**: One-way ANOVA test revealed that there was no statistically significant difference between the three groups. The highest tensile bond strength between PEEK and composite was seen in Group 2(BioHPP and Bredent) and least bond strength was seen in Group 1(BioHPP and Shofu). **Conclusion**: Within the limitations of this invitro study, the mean value of tensile bond strength was higher in Group 2 (BioHPP and Bredent) when compared to other groups.

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INTRODUCTION

Today, dentists and patients have several choices when it comes to the materials that are used to restore teeth. Among those are the composite resins because of their physical, optical, mechanical properties, ease of handling and ability to be bonded to the tooth structure or veneering to other materials. Composite veneered metal crowns are known to have the highest durability and longevity in service as opposed to the metal-ceramic crowns and they have been proposed as an alternative veneering method, a high strength indirect composite resin veneering on peek substructure has been proposed.Polyetheretherketone (peek) is a biocompatible, high-temperature thermoplastic, semi-crystalline material with high melting temperature. In medicine, it has been utilised as a substitute for titanium in orthopaedic applications and as an implant, provisional abutment, implant supported bar, or as clamp in the prosthetic dentistry. However, from the aesthetic point of view, it still requires veneering owing to its low translucency and grayish pigmentation. Therefore, an advanced form Biohppwhich is a hybrid peek-based, ceramic-reinforced high-performance polymer was introduced. It is the most widely used high performance polymer in dentistry. In their studies, **Jivkogeorgiev et al (2018),[1]Schwitalla a, Müller wd(2013)[2]** showed that Biohpp may be an alternative material for the production of removable partial dentures, crown and bridge fabrication and dental implants due to the combination of its mechanical properties and high biocompatibility.**Christine keul et al (2014)[3]** stated that peek surfaces and veneering resin composites have low surface energy and resistance to surface modification by different mechanical and chemical treatments. The current procedures such as airborne particle abrasion, acid etching, plasma or laser techniques are used to prepare the surface. Nevertheless, knowledge concerning the potential and limitations of this material in adhesion to resin composites is insufficient.**Yousef jahandideh et al (2020)**[4]stated that the shear bond strength, pull-out, tensile and micro tensile tests have been suggested to measure the stress distribution which further affects the bond strength. However, since the clinical setting is more complex, the results of in vitro studies should be interpreted with caution. Thus, tensile bond strength was used in this study. The aim of the study was to evaluate the tensile bond strength of three types of composites (gradia, bredent and shofu) and to compare the tensile bond strength when veneered to Biohpp (peek).

METHODOLOGY

PREPARATION OF SPECIMEN

A total of 60 specimens were fabricated from a Biohpp (peek)(bredent) blank using a standard tessellation language (stl) file which was given as an input in the software (siemens nx12) for cad-cam (computer aided designing-computer aided milling)(sironainlab mc x5) with dimensions of 8 x 8 x 12mm. After milling of the specimens, dimensions of the specimens were checked using digital vernier calipers and were subjected for surface treatment by sandblasting with 110µm aluminium oxide with 4 bar pressure at 3cm distance at 60-90° angle for 10 seconds.

BONDING PROCEDURE AND PREPARATION FOR TENSILE BOND STRENGTH MEASUREMENT

The 60 Biohpp (peek) specimens were randomly divided into three groups for three veneering composites with twenty specimens in each group (n = 20).

GROUP 1 CERAMAGE (SHOFU)

A thin layer of ceresin bond I was applied on the Biohpp (peek) surface and air dried for 10 seconds, subsequently, a single layer of ceresin bond ii was applied and light polymerized for 1 minute with solidaliteV- curing light (shofu). Ceramage layering was done by condensing first layer of composite till the half of hour glass shaped index, which was light cured for 5-20 seconds. Consecutively, the second layer of 1mm was done filling the whole putty index and final curing was done for 1 minute.

GROUP 2 CREA.LIGN (BREDENT)

For bredent, visio.link (bredent) adhesive was applied over the Biohpp surface in thin layer and polymerized for 90 seconds in special light curing chamber (bre.lux power unit) at 370-400nm wavelength as per the manufacturer's instructions. The layering was done by placing first layer till the half of the hour glass shaped index with intermediate curing of 180seconds and second layer was placed filling the putty index and light curing was done for 180seconds. The final curing was done for 360 seconds.

GROUP 3 - GCGRADIA

GC ceramic primer (gradia) was applied and light cured for 30 seconds. After that, each layer of composite was placed filling half of the hour glass shaped index, which was light cured for 40 seconds and then complete filling of the putty index was done which was light cured for 40 seconds using GClabolight duo (gradia) with a wavelength of 375-570nm and then it was kept for final curing for 3 minutes as per the manufacturer's instructions.

PREPARATION OF PUTTY INDEX FOR VENEERING OF COMPOSITE

An hourglass figure was designed with dimensions of 6mm diameter at the base, 3mm at the center and 2mm length using an STL file software (siemens nx12). Then a resin model was printed by a 3D printing machine (phrozen sonic mini 4k). The resin model was placed on the Biohpp specimen and then a putty index was made which was used for layering of the composite.The specimens were held in the universal testing machine(UTM) with the help of a ligature wire which was twisted at the neck of the composite specimen using 2 cut wires of 4 inches each, which were placed on either side of the specimen and twisted up to hold the composite specimen by which they were held in the jig of the universal testing machine (UTM) and testing for the tensile bond strength was done.

TENSILE BOND STRENGTH MEASUREMENT

Tensile bond strength was determined in a universal testing machine at a crosshead speed of 5mm/minute. Specimens were positioned in the jig of the testing machine to the loading direction using a special test configuration, which provided a moment-free axial force application. In the lower jig, the Biohpp (peek) specimen was held and in the upper jig, the ligature wire which was attached to the composite specimen was held and the bolt was tightened. The jig was attached to the load cell and pulled apart by an upper and lower chain, allowing the whole system to be self-aligning. The tensile bond strength was calculated with the following formula: fracture load/bonding area; N / mm²= Mpa.

All the three groups (group A, group B and group C) values were recorded at which force(N) the specimens got debonded. These values were used to find the tensile bond strength of each individual group. Subsequently, descriptive analysis was conducted and one way ANOVA was conducted to find the group difference.

RESULTS

Themean of Group-A (shofu) samples was 51.00 and the standard deviation was 16.00. The mean of Group-B (bredent) samples was 57.30 and the standard deviation was 21.01.

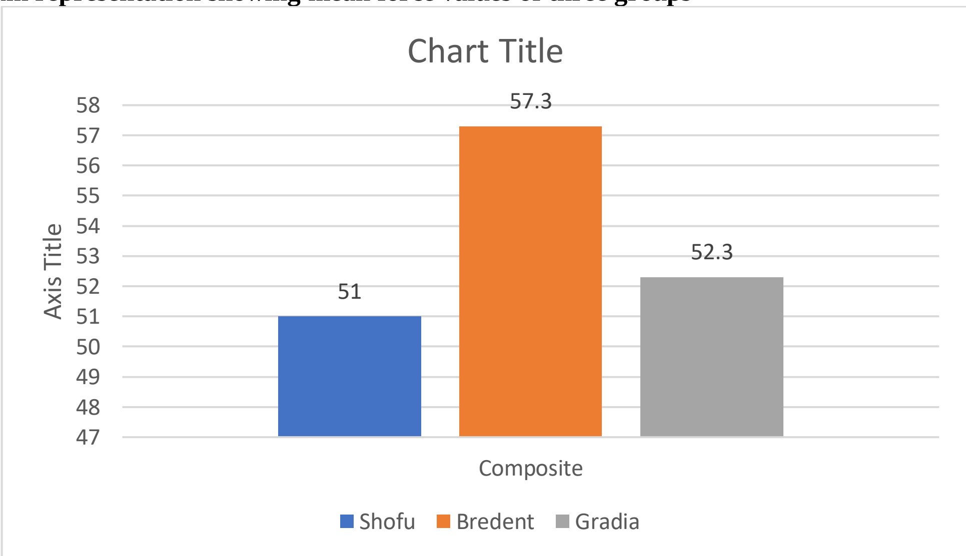
The mean of Group-C (gradia) was 52.30 and the standard deviation was 14.27. One-wayAnova test was performed to compare the mean difference amongst three different groups. The test showed p value of 0.48 for the three composites. Hence, there was no significant difference between the three groups.Tensile bond strength for the three groups was assessed and group-B has the maximum tensile bond strength which is 3.36mpa

Group	Tbs maximum	TBS minimum
A	2.93 mpa	0.81 mpa
B	3.36 mpa	0.53 mpa
C	2.65 mpa	0.88 mpa

Composite	Load		P value	Post hoc analysis
	Mean	SD		
Shofu	51.00	16.00	0.48	NA
Bredent	57.30	21.01		
Gradia	52.30	14.27		

Illustrations

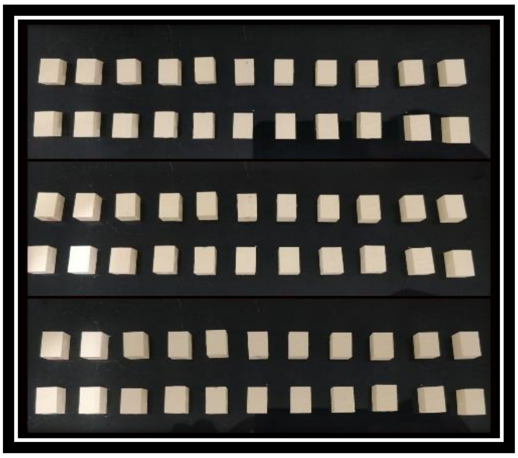
Bar diagram representation showing mean force values of three groups



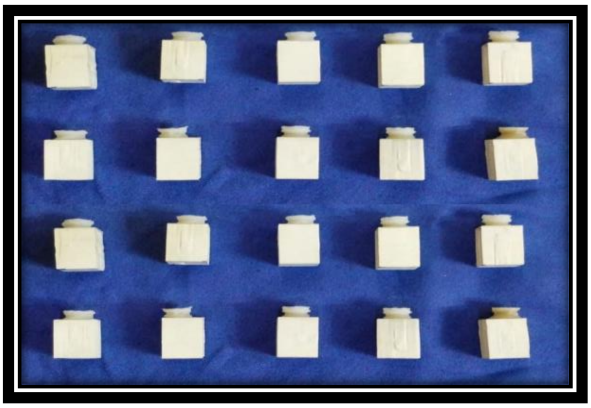
DISCUSSION

The present study focused on the tensile bond strength of three types of composites (gradia, bredent and shofu) veneered to Biohpp (peek). Durable bonding to veneering materials is required to ensure an adequate functional

outcome and long-term stability. **Younis M et al**[5] stated that adequate bonding between peek and veneering resins remains a key factor in ensuring long-lasting survival and success rates.



The first step in this study was preparation of the specimens. In this study, specimens were milled from a prefabricated PEEK blank by giving input in the form of standard tesselation language (STL) file to the cad-cam machine which gave good accuracy in terms of precision and trueness and the elimination of laboratory errors which was in accordance with **StawarczykB et al**[6] who stated that excellent mechanical and optical properties were seen in cad/cam milling **(Jiang h et al (2022)**[7]**.**However, the low translucency of peek still limit its use as a monolithic, anatomic contour dental restorative material. Thus, additional veneering is required to obtain satisfactory esthetics [**Hasan Sarfaraz H et al (2020)**[8]**],** this limitation can be overcome by layering peek frameworks with composite resins to achieve a better shade and translucency **[Ates M et al**[9]**].**Air abrasion was done by sandblasting them using aluminium oxide with 4 bar pressure for surface roughness which has been shown to play an important role in the bonding technique for adhesives in accordance **with Keul. C et al (2014)**[3]**, Sarfaraz H et al (2020)**[8]**. Attia maet al**[9] stated that the mean bond strength value for the peek posts airborne-particle abraded with 50-mm al_2o_3 was significantly higher than that for the untreated peek posts which is in conformity with the present study,**Liu H et al**[10]**,** the improved bond strength could be attributed to the increased surface roughness of the peek surface after airborne particle abrasion, allowing for micromechanical bonding with methyl methacrylate-based resin cement**.**[11,12] in contrary to the present study**Sarfaraz H et al**[8] stated that the air abrasion without a primer can result in high strength, but the strength of the bond decreases sharply even to zero over time. **StawarczykB et al**[14] assessed the tensile bond strength between different veneering resins and peek after pre-treatment with different primers and adhesives. Only visio.link and signum peek bond I+II significantly increased the bond strength between peek and the veneering resins. The above study is in conformity with the present study.After the fabrication step, three types of composite ceramage(shofu), crea.lign(bredent), GCgradia were used to evaluate their tensile bond strength with Biohpp (peek) in accordance with the studies done by **BeleidyM et al**[15]**, Attia ma et al**[9]**.**In this study, as per the manufacturer's instructions, ceresin bond I and air drying it for 10 seconds and then one layer of ceresin bond ii was applied and light cured for 1 minute under solidaliteV curing unit. In the present study, cohesive bonding



was seen in accordance with the study by **Sarfaraz H et al[8]** used ceresin bond I which was applied and air dried and then ceresin bond II was applied in one layer and light polymerized for veneering shofu composite to peek. And also explains that by rewetting effect of primer or "healing" of minor surface defects on the airborne-particle abraded the surface. In addition, the phosphonate monomers of the primer can develop a oxide bond in the substrate and have resin terminal end groups, which can enable cohesive bonding.For bredent, visio.link was applied on the biohpp surface in thin layer and polymerized for 90 seconds in special light curing chamber (bre.lux power unit)at 370-400 nm wavelength. **LümkemannN et al[16]** stated that the highest bond strength for all peek compositions was achieved after polymerizing visio.link using halogen light curing units for both chairside or labside application. In the present study, for testing tensile bond strength, a universal testing machine was used, the newton of force was evaluated at the time of debonding of composite with the crosshead speed of 5mm/min which is in accordance with the study conducted by **Stawarczyk b et al[14]** but **A. Della bona and Van noort[17]** and **Rikitokus et al[18]** used the universal testing machine (lloyd m5k tester) for tensile bond strength at a cross-head speed of 1.0mm/min.Which are not in accordance with the present study.In this study, force values of group a (biohpp and shofu composite) showed the maximum value of force was 83 n. Which is in accordance with the study done by **Najeeb s et al[9]** in their study showed maximum tensile bond strength test of 80 mpa for peek. **Tannous f et al[20]** showed the tensile bond strength of force which was measured for peek was maximum 97 mpa.The mean standard deviation of groups A,B,C were 16,21.01,14.27 which are very nearly synonymous with the results of **Rikitokus et al[18]** which showed 11.51, 14.26 and 16.00 and **Keul c et al[3]** who in their study showed mean standard deviation of 18.4 for signum composite dentin and 20.7 for signum ceramis dentin when veneered to peek.The present invitro study has limited itself from the assessment of properties such as shear bond strength, mechanical properties and microstructural characteristics of fractured surfaces for different bonding agents so longitudinal clinical trials are still needed to evaluate the tensile bond strength of composite veneered to peek specimen when prepared with different bonding agents and also to know about their surface characteristics.

CONCLUSION

Surface treatment methods of PEEK and the adhesion of PEEK to resin-matrix composites has been discussed in this study. The highest tensile bond strength between peek and composite was seen in the group (biohpp and bredent) of 2.02mpa.Nevertheless, the adhesion of PEEK to resin-matrix composites is still a current issue in clinical practice. Hence, further studies are needed to address the lack of lacunae of literature.

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