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Comparative Evaluation of Shear Bond Strength of Prefabricated Composite Veneer Bonded to PolyEther-Ether Ketone Framework using two Different Bonding Systems: an Invitro Study

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Abstract

Objectives:

The aim of this study was to evaluate and compare the shear bond strength of prefabricated composite veneer bonded to polyether-etherketone(PEEK) implant prosthetic framework using two different bonding systems.

Materials and methods:

40 pre-fabricated composite veneers (novo.lign A -bredent GmbH,Germany) for central incisors were selected and cemented to a PEEKframework using two different bonding systems–Group A using visio.link primer-combo.lign luting composite resin (bredent GmbH,Germany) and Group B using GC Composite Primer(GC,Europe) and LuxaCore Z bonding resin(DMG, Germany).After ageing the specimens by storage in distilled water at room temperature for 24 hours, shear bond strength of composite veneer bonding was tested on universal testing machiene.

Results:

Shear bond strength valueswere more for Group A (5.95MPa) than Group B (3.19MPa) which was statistically significant. SEM analysis showed that mixed type of bond failure were more commonly observed in thebonding systems.

Conclusion:

Shear bond strength of visio.link-combo.lign bonding system was more than GC composite primer-LuxaCore Z bonding system. The type of bond failure was mostly mixed failure in both the groups along with cohesive failure within the veneer suggesting that the veneering system was not appropriate for the PEEK frameworks.

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I. Introduction:

As implant dentistry is gaining more and more acceptance, the focus of implant fixed prosthesis has shifted towards the establishment of esthetic coloured materials, with the help of hybrid prosthesis using acrylic or composite veneered over a framework, rather than establishment of osseointegration alone.High esthetic demand of patients necessitates the use of tooth coloured framework material. Zirconia, though a tooth coloured material, is not affordable to the common man due to its high cost and its complexity in fabrication technique.[4, 5]The advent of polyether-etherketone (PEEK) a relatively new material in medicine and dentistry is an economic alternative for such situations.[6,7]PEEK is used in various medical applications because of its excellent chemical, mechanical, and thermal properties. It has high strength combined with adequate milling and grinding properties.

PEEKis white in colour, chemically stable, has elasticity within the range of bone, radiolucent and biocompatible.[9]It has a higher level of design freedom and functional integration and at the same time is an economic alternative to precious metals or other materials. They are non-abrasive to natural teeth, has low density, are plaque resistant and highly polishable.[10, 11, 12]Thesemakes PEEK an excellent biocompatible material specially optimized for the dental field. PEEK blanks have a grayish brown or pearl-white opaque colour and have low translucency. Thus, veneering is required to obtain satisfactory esthetics.[2, 13] But bonding to resin-based materials remains a challenge because of the complex chemical structure and low surface energy of PEEK.[14]Achieving adequate bond strength between veneering resin composites and PEEK surface is one of the requirements for good functional outcome and long-term stability. This can be achieved by chemical adhesion, mechanical adhesion or a combination of both.[15]

Previous studies screened the bonding ability between PEEK and composite resins and stated that no, or only insufficient, values can be achieved without any further treatment of the PEEK surface.[3,15,16] These studies also showed that additional adhesive systems are essential in establishing a strong bond to composite resins. But information regarding the bond strength of PEEK material to dental materials is scarce. Hence this invitro study was done to evaluate the shear bond strength of prefabricated composite veneer bonded to PEEK implant prosthetic framework by using two different bonding systems PMMA primer with composite resin cement, and composite primer with resin cement.

II. Materials and methods:

Selection of prefabricated composite veneer:

40 pre-fabricated composite veneers (novo.lignA-Bredent GmbH,Germany) of central incisor of the same mould were selected(Fig: 1). Elastomeric impression of the bonding surface of veneer was made. Bonding surface of veneer was divided into known geometrical shapes like trapezoid and rectangle for calculating the surface area of the bonding region. Thus the surface area was calculated as 75.5mm.[2]

Fabrication of PEEK framework:

40 chrome-cobalt metal core structures were fabricated by casting 4 mm sprue former with a 3 mm casting wax attached to one end at 45 degree. The core structures were adapted

to the fitting surface of selected novo.lignAveneers. Wax up was made by filling wax between the fitting surface of veneer and the metal core. Wax pattern was then removed along with the metal core and attached to a 4 mm sprue former and invested in special phosphate-bonded investment material (Brevest, bredent, GmbH,Germany) for for2press machine. The pre-heating process for melting the wax and controlling the expansion of the investing material was done in a pre-heating oven at 850º C for one hour. After dewaxing, PEEK material (Bio-HPP,bredent,GmbH, Germany) was pressed in a for2press pressing unit at 400°Cat 3.5 Kg/cm^2 pressure. Each frameworkalong with the metal core was then mounted onto a metal housing of 2×2.5×2.5 cm size using acrylic (DPI, India) (Fig:2).

Samples were then divided into two groups, Group A and Group B, each containing 20 samples each.novo.lignA prefabricated veneers were taken and sandblasted on its fitting surface with 110µm alumina particles at 2kg pressure for 20 seconds and at a distance of 10 mm. The surface was then cleaned with oil-free compressed air.PEEK frameworks were then sandblasted with 110µm alumina particles at 2kg pressure for 20 seconds and at a distance of 10 mm perpendicular to treated surface without water contamination.

Cementation of veneer

ForGroup A, visio.linkprimer (bredent, GmbH, Germany) was taken in a disposable tray and a thin layer was applied on the veneer using disposable brush. It was then light polymerized for 90 seconds using Bre.Lux Power Unit(bredent, GmbH, Germany). Then a thin layer of visio.link primer was applied on to PEEK surface and light cured for 90 seconds. Veneer was then bonded to PEEK framework (Fig: 3) by using combo.lign luting composite resin (bredent, GmbH, Germany). Excess cement was removed with an explorer and the veneer –PEEK complex was light cured for 180 seconds as per manufacturer instructions using Bre.Lux Power Unit. For Group B, similar procedure was done by using GC Composite Primer (GC, Europe) and LuxaCore Z bonding resin (DMG, Germany).

Ageing of the samples

Ageing of all the specimens were done by storing them in distilled water at room temperature for 24 hours.

Shear bond strength measurements

Shear bond strength was measured with a Universal Testing Machine (Model H10KS, Tinius Olsen). The bonded specimens were mounted in the jig of universal testing machine with a special fixture. The loading piston in a chisel configuration was placed close to incisal edge of the veneer. The load was applied to the specimen which was mounted at an angle of 45° and with a crosshead speed of 1 mm/min (Fig:4&5). Load at failure was recorded and shear strength values were calculated according to the equation,

$$\boldsymbol{\sigma = F/A,}$$

where σ = the shear bond strength (MPa) ,

F = the load at failure (N) and

A = the adhesive area of the veneer (mm^2) and were tabulated for both the groups. A sample from each group was then examined under Scanning Electron Microscope (Carl Zeiss, Zigma model) to examine the debonded surface (Fig:6) and analyse the failure type.

Fig 1 Novolign A Veneers

Fig 2Mounted PEEK framework

Fig 3 PEEK Framework with Veneer Attached for group A & group B

Fig4 Specimen Mounted for Shear Bond Testing

Fig 5 Specimen after Testing

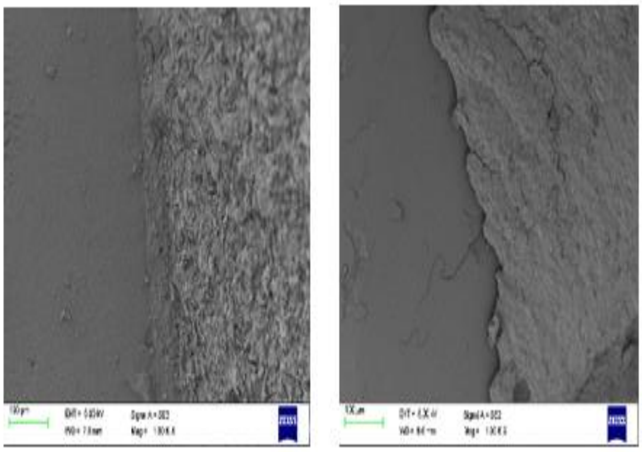

Fig 6 SEM Analysis of Debonded Surface group A & B

III. Results:-

All the specimens were subjected to shear bond strength test in Universal Testing Machine. The loads resulting in bond failure was obtained from the universal testing machine software. The load was recorded in Newton and the shear bond strength was calculated and tabulated.Table: 1 shows the Mean Values and Standard Deviations of the maximum load at bond failure for both the groups.Table: 2 shows the Mean Values and Standard Deviations of the shear bond strength of both the groups.Table: 3 shows Independent Samples t- Test for Shear Bond Strength of the samples.

The statistical analysis was performed using commercially available software (SPSSs11, SPSS Inc., Chicago, IL, USA). Paired t-test was used to determine significant differences at significance level set at $p \leq 0.05$(Table 3). On comparing the groups there was a statistically significant difference in shear bond strength between group A & group B ($p<0.05$). Group A had the highest mean value of 5.95MPa when compared to Group B (3.19MPa). Since p value was 0.00 which was less than 0.05 after the t-test, the result was statistically significant. Hence the shear bond strength of Group A is significantly higher than Group B.

SEM analysis revealed thatmixed type of bond failure were more commonly observed in both Group A and Group B.

Table: 1 Mean Maximum Load at Bond Failure (N) and Standard Deviation

Group	N	Mean	Standard Deviation
Group A	20	450.50	41.852
Group B	20	241.45	48.369

Table: 2 Mean Shear Bond Strength (Mpa) and Standard Deviation

Group	N	Mean	Standard Deviation
Group A	20	5.9593	0.5521
Group B	20	3.1930	0.6411

Table: 3 Independent Samples Test For Shear Bond Strength

	t-test for Equality of Means		
Group A and Group B	T	Df	Sig.(2-tailed)
Equal variances assumed	14.620	38	.000

IV. Discussion:

The study aimed to evaluate the shear bond strength of prefabricated composite veneer bonded to PEEK implant prosthetic framework by using two different bonding systems -visio.link-combo.lign bonding system and GC composite primer - Luxacore Z bonding system. The result concluded that Visiolink - Combolign bonding system is superior to GC composite primer- Luxacore bonding system.

In the current study, the highest adhesion was observed in groups conditioned with Visio.link when compared to GC primer. This may be because Visio.link contained pentaerythritol triacrylate, MMA monomers and dimethacrylate giving best results. Therefore, it can be assumed that MMA caused the PEEK surface to swell and that the dimethacrylate monomers provided the connection to the composite resins with 2 carboxyl groups as binding sites. In contrast, the use of GC primer containing 2-hydroxyl-ethyl methacrylate (HEMA), tetrahydrofurfuryl methacrylate and urethane dimethacrylate (UDMA) groups, resulted in less retention strength to the PEEK substrate or the composite resin. The reason for this lower adhesion between PEEK and GC primer could be a lack of MMAmonomers.

SEM evaluation of representative sample for each group has showed mixed type of bond failure with group A and B. There is no true adhesive failure in any of the case. The fracture pattern was initiated by the cohesive fracture of the veneer used.None of the PEEK abutments underwent fracture. This again highlights the mechanical advantages of PEEK material in dentistry. Mass produced veneers like novo.lign (bredent GmbH, Germany) used in the present study were new arrivals in dental field.[10] These are high impact PMMA composite veneers.Hence it could be concluded that cohesive strength of novo.lign veneer has to be improved.

From a methodological point of view, a shortcoming of this study was the lack of artificial aging by thermal cycling or long-term water storage. Laboratory tests that determine bond durability use long-term storage and thermal cycling as a means of artificial aging. In the current study method used was storage in distilled water for 24 hours at 37ºC. [2] Another shortcoming of the study was on the method used to calculate the surface area of the prefabricated veneer. Scanning the surface with a computer system is a more precise approach to surface area calculation compared to the method used in this study.[17]

V. Conclusion

The study aimed to evaluate the shear bond strength of prefabricated composite veneer bonded to PEEK implant prosthetic framework by using two different bonding systems -Visio.link- Combo.lign bonding system and GC composite primer - Luxacore Z bonding system.The results showed that Visiolink - Combolign bonding system is superior to GC composite primer- Luxacore bonding system.However, the cohesive strength of the veneer has to be improved to give better bond strength. In addition, incorporation of mechanical or micromechanical retention may help to get better retention.

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