



# BIOHPP: PROPERTIES AND APPLICATIONS IN PROSTHODONTICS

## A REVIEW

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### ABSTRACT

**Introduction:** The demand for metal free restorations may it be fixed or removable has increased manifold in the recent past. BioHPP is one such material that has been introduced recently in the field of prosthodontics.

**Aim:** The aim of this narrative review is to discuss the properties of BioHPP (Biocompatible High Performance Polymer) material and its applications in the field of prosthodontics

**Materials and Methods:** A search strategy was performed on PubMed and Google Scholar with key words: Modified PEEK, BioHPP, Prosthodontic applications.

**Results:** Seventy nine articles were retrieved. After hand search and along with cross reference a total of 84 articles were identified. Ultimately 18 articles were selected and discussed as they met the selection criteria.

**Conclusion:** Within the scope of this review, reported literature showed that BioHPP has proven to be a boon to the field of prosthodontics as a result of its excellent biocompatibility as well as mechanical properties. BioHPP offers a wide range of applications may it be in removable or fixed prosthodontics. With an increase in the number of clinical trials and long term follow up studies, BioHPP might prove to be a material of choice for a variety of prosthodontic applications.

**KEYWORDS:** Modified PEEK, BioHPP, Prosthodontic applications.

<http://dx.doi.org/10.19177/jrd.v7e4201972-76>

### INTRODUCTION

A variety of materials are used in the field of prosthodontics for restoration of various scenarios of edentulousness, may it be a removable prosthesis or a fixed dental prosthesis. The increasing demand for metal free or tooth coloured aesthetic restorations,

motivated researches to search for substitutes for the conventional metal-based materials. Ceramics have been introduced in dentistry as bio-inert or bio-active coatings for several years but have certain limitations in their usage owing to their inherent brittleness and low fracture toughness. This led to the development of PEEK (Polyether ether

ketone); a biopolymer which can be used as dental implant materials as well as a material suitable for frameworks of removable prostheses and has been successfully used in operations carried out on humans for many years. BioHPP (Biocompatible High Performance Polymer) is one such variant of PEEK

that has been specially optimised in the dental field.<sup>1-2</sup>

**MATERIALS AND METHODS**

A search strategy was performed on PubMed and Google Scholar with key words: Modified PEEK, BioHPP, Prosthodontic applications.

**RESULTS**

Seventy nine articles were retrieved. After hand search and along with cross reference a total of 84 articles were identified. Ultimately 18 articles were selected and discussed as they met the selection criteria.

Inclusion Criteria: 1. Peer reviewed articles in English only. 2. Full text articles – reviews and studies

Exclusion Criteria: 1. Abstracts only on the databases searched 2. Articles not related to dentistry

**DISCUSSION**

**WHAT ARE BIOPOLYMERS?**

Biopolymers are polymeric biomolecules which contain monomeric units that are covalently bonded to form larger molecules. The prefix ‘bio’ means they are biodegradable materials produced by living organisms. Biopolymers are complex molecular assemblies having a defined 3D shape and structure as against the synthetic

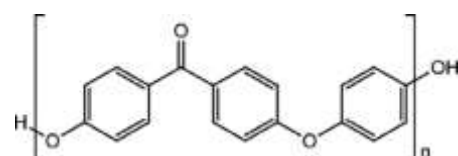


Fig 1. Chemical structure of PEEK

polymers which have a simple and random structure. Their defined shape and structure are indeed keys to their function.<sup>3</sup>

PEEK is a semi-crystalline, linear, polycyclic aromatic polymer (-C<sub>6</sub>H<sub>4</sub>-OC<sub>6</sub>H<sub>4</sub>-O-C<sub>6</sub>H<sub>4</sub>-CO-)n (Fig.1) which was developed by a group of English scientists in the year 1978 and it began to gain popularity in dentistry by the late 1990’s.<sup>4</sup>

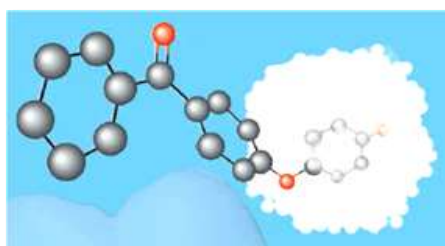


Fig 2. Structural Formula of BioHPP: white cloud indicating ceramic filler

BioHPP is a partially crystalline, thermoplastic high-performance polymer which is a modification of PEEK developed by Bredent GmbH. It contains 20% ceramic filler with a grain size of 0.3µm to 0.5µm(Fig.2). Constant homogeneity is produced in the material owing to this small grain size of the ceramic filler. This is a prerequisite for optimising the mechanical properties, making it useful for dental technical and/or dental medical use in crown and bridge area.<sup>5</sup>

**PROPERTIES OF BIOHPP**

Certain properties of BioHPP are listed in the table given below (Table 1). These properties were scientifically and clinically assessed during in vitro tests which were carried out in co-

Table 1: Properties of BioHPP

<b>Mechanical Properties DIN EN ISO 10477</b>	
Elastic Modulus	4000MPa
Flexural Strength	>150MPa (no material failure)
Water Absorption	6.5µg/mm <sup>3</sup>
Water Solubility	<0.3µg/mm <sup>3</sup>
<b>Mechanical Properties after 10,000 thermocycling cycles 5°C / 55°C DIN EN ISO 10477</b>	
Elastic Modulus	4000MPa
Flexural Strength	>150MPa (no material failure)
<b>Breaking Load Tests on 3 part bridges</b>	
Maximum load without failure (after 24 hr immersion in water, 37°C)	>1200N
Maximum load without failure (after mechanical and thermal alternating load 1.2 million x 50 N, 10,000 x 5°C / 55°C)	>1200N
<b>Other Properties</b>	
Melting Range	Approx 340°C
Bond Strength	>25MPa
Hardness	110HV



Fig 3a. BioHPP granulate material



Fig 3b. BioHPP Prefabricated Cylinders

operation with Jena University (Outpatient Department for Dental Prosthetics and Materials) and Regensburg University (Specialist field of Dental Prosthetics).<sup>6</sup>

BioHPP prostheses can be fabricated either by the conventional lost wax technique or via the CAD/CAM manufacturing i.e. it can either be pressed or milled. It is therefore available under two different trade names i.e. BioHPP and breCAM.BioHPP for pressing and milling respectively. BioHPP is available in two forms- granulate material(Fig.3a) and prefabricated cylinders(Fig.3b). They are supplied in transparent plastic tubes which protects it from moisture. For the

purpose of milling, breCAM.BioHPP is available in the form of round blanks(Fig.4). The properties of the material remain the same irrespective of the method of fabrication.<sup>7</sup>

#### APPLICATIONS OF BIOHPP IN REMOVABLE PROSTHODONTICS

Fabrication of removable partial dentures has been proven to be successful for the treatment of partially edentulous cases. The alloys used conventionally for the fabrication of the RPD frameworks like Nickel(Ni), Cobalt(Co), Chromium(Cr) and Molybdenum(Mo) have a variety of advantages like high strength, corrosion resistance and relatively low cost.<sup>8-9</sup> These conventional metal frameworks were uneasthetic<sup>10</sup>, exert forces on the abutment teeth that exceed those capable of producing tooth movement<sup>11</sup> and also may cause allergy in certain individuals.<sup>9</sup> This led to the introduction of thermoplastic materials like nylon and acetal resin which produced better aesthetics

and reduced forces on the abutment teeth due to lower modulus of elasticity but the major drawback was the inability to be relined and lack of natural translucency respectively.

BioHPP overcomes these disadvantages and has been proven to be a successful alternative for the fabrication of RPD frameworks. BioHPP is as elastic as bone with an elastic modulus of 4GPa thereby reducing the stress on the abutment teeth. Also, the white colour of the material gives an aesthetic appearance. Clasps made up of BioHPP are gentler on the enamel and the porcelain restorations as compared to the conventional Co-Cr clasps. Also, the periodontal health of the abutment teeth is maintained due to its low plaque affinity. According to Tannous et al, PEEK clasps offer a lower retentive force than metal clasps; however, properly designed PEEK clasps with an undercut of 0.5 mm could provide adequate retention for clinical use.<sup>8</sup> The bond strength of BioHPP with PMMA and indirect composite materials is high with the use of a PMMA and composite primer (visio.link; Bredent GmbH & Co. KG).<sup>9</sup> Therefore a prosthesis with a framework of BioHPP can be easily



Fig 4. breCAM.BioHPP in round blank

relined in cases of resorption since the denture base material used is heat cure acrylic resin. The weight of the prosthesis is considerably less as compared to the conventional RPDs as BioHPP has low specific weight thereby increasing patient comfort and satisfaction.

#### APPLICATIONS OF BIOHPP IN FIXED PROSTHODONTICS

The long term clinical success of any dental restoration greatly relies on the selection of the material for the prosthesis. The selected material influences the mechanism of the stress transmission to the underlying abutment tooth or implant during function.<sup>11</sup> Considering the properties of BioHPP, it can be used for the fabrication of framework for FDPs, endocrowns, interim restoration after implant placement, implant abutments and implant frameworks.<sup>12-15</sup>

Mostafa et al conducted a study to evaluate the marginal adaptation and fracture resistance of BioHPP and zirconia. They concluded that Bio HPP framework showed statistically significant higher fracture resistance than Y-TZP Zirconia. Also, the BioHPP FDPs showed better marginal adaptation but it was statistically non-significant. Thus, BioHPP can be potentially used as crown and bridge material even in posterior area.<sup>16</sup>

Another study was conducted by Roqaiya M Al Assar et al to compare the fracture resistance and retention of lithium disilicate (IPS emax) and PEEK(BioHPP) Inlay Retained Fixed Partial Dentures(IRFPDs) fabricated with heat press technique and CAD/CAM system. They concluded that both the retention and fracture resistance of metal free inlay retained bridges were

affected by both material type and construction method.<sup>17</sup>

Jin et al conducted in vitro study was to evaluate and compare the bond strength of modified PEEK (BioHPP) and titanium with a veneering composite resin and compare the marginal fit and fracture resistance of implant-supported screw-retained FDPs fabricated by using computer-aided design and computer-aided manufacturing (CAD-CAM) frameworks veneered with composite resin. Significantly higher shear bond strengths were obtained in group BioHPP (31.1 ±3.5 MPa) than in group Titanium (20.5 ±1.8 MPa). The mean marginal gap width was 19 ±4 mm in group BioHPP and 16 ±6 mm in group Titanium. Statistical tests showed no significant differences ( $P>.05$ ). After loading, veneering chipping was observed at a load of 1960 ±233 N in group Titanium. Although the BioHPP frameworks fractured at 1518 ±134 N, no chipping occurred. The study concluded that the bond strength of BioHPP with the composite resin was greater than that of titanium. CAD-CAM BioHPP frameworks exhibited good marginal fit and fracture resistance. BioHPP may be a suitable alternative to metal as a framework to be veneered with composite resin.<sup>2</sup>

Wagner et al conducted a study to investigate the retention loads of differently fabricated secondary telescopic polyetheretherketone (PEEK) crowns on cobalt-chromium primary crowns with different tapers. It was found that, among the manufacturing methods, both pressed groups showed no impact of taper on the retention load values, whereas among the milled secondary crowns, the 0° taper showed significantly lower retention load values

than the 1° and 2° taper. Thus, the study concluded that telescopic crowns made of PEEK seem to show stable retention load values. In addition, further developments in CAD/CAM manufacturing of PEEK materials for telescopic crowns are warranted, especially for 0°.<sup>7</sup>

BioHPP is a very attractive material in implantology due to its excellent mechanical properties as well as biocompatibility. It is not only used as a framework for removable prostheses but also as frameworks in implant supported prostheses along with being used as an abutment for the implant. Also, BioHPP can be used for fabricating an immediate definitive abutment or an immediate framework after implant placement for provisionalization.<sup>15</sup> BioHPP is considered as a suitable material for abutments and frameworks because it reduces the transmission of stress to the underlying implant and thus stimulates the bone remodelling around the implant.<sup>18</sup>

Another advantage of BioHPP is that it is radiolucent thus enabling the clinician to assess excess cement around a cement retained prosthesis. But in case of a screw retained prosthesis, the radiolucency of the material proves to be a disadvantage as it limits the ability to assess the complete seating of the prosthesis.<sup>15</sup>

#### CONCLUSION

BioHPP has shown to be a boon to the field of prosthodontics as a result of its excellent biocompatibility as well as mechanical properties. It is thus proving to be a suitable material for a variety of applications in the field of prosthodontics may it be fixed or removable prostheses.

## CLINICAL SIGNIFICANCE

A number of long term clinical trials with follow up studies as well as comparative studies for the use of BioHPP are required. Nevertheless, this material holds a great potential to fulfil the demands of the patients in terms of aesthetics and metal free restorations.

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