

REVIEW ARTICLE

PEEK IN PROSTHODONTICS: A REVIEW

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ABSTRACT

Main purpose of dentistry is to deliver best dental care without causing any harm to the patient. To fulfill this purpose many developments and improvement in quality of several materials have come into existence in recent year. One such newly advanced material in dentistry is PEEK. PEEK is a metal free, semi-crystalline, high performance, beige-brown color material with excellent mechanical properties. This article is aimed to review on the clinical application of PEEK in Prosthodontics. An electronic literature search was done via PubMed, Embase, Google scholar and 20 full text articles were included for this review.

Keywords: Peek, Prosthodontics, Implant, Abutment

INTRODUCTION

In dentistry by improving or modifying materials we can reach advancement in dentistry and improvement of technologies. Materials used in advanced dentistry should be non-toxic, non-irritant and compatible to oral structures, good in esthetics. Dentist can restore dental deformities by using fixed or removable restoration. For restoring masticatory function in best way possible dentist should use scientifically approved, biocompatible and high-performance material. One such newly advanced material available in the market is PEEK. So, the question arises, what does PEEK stands for? The answer is it stands for Polyetheretherketone. PEEK, also known as polyaryletheretherketone, belongs to the PAEK polymer family.¹PEEK is a polyaromatic semi-crystalline thermoplastic polymer that is metal-free, colorless, and high performing. Victrex PLC and ICI introduced PEEK for the first time for engineering use in the 1980s (Imperial Chemical Industries)². At initially, it was produced for compressor plate valves, cable insulation, turbine blades, and piston parts. Then, through Invibio Ltd., it was proposed for biomedical software in 1998. (Thornton-Cleveleys, UK). PEEK Optima was offered for implant use later that year.³ Based on numerous in-depth PEEK research studies conducted in recent years, its outstanding performance has caught the

interest of scientists working in the field of stomatology. PEEK has comparable mechanical properties and characteristics to that of bone and hard tissue and its hue resembles that of a tooth, demonstrating its enormous potential for use in fixed and removable prosthodontics.⁴

PEEK AS AN IMPLANT MATERIAL

Since Branemark developed titanium for dental implants, it has been a popular material in implant dentistry and is believed to be safe with a high success rate. However, incidences of implant failure have been described in the past that may have been brought on by biological or biomechanical issues. Peri-implantitis, corrosion, bacterial contamination, and subpar aesthetics are typical issues with titanium implants. According to recent studies, 15% to 20% of titanium dental implants exhibit hypersensitivity. New materials are being developed in order to solve all of these issues.⁵ PEEK is a newly advanced material in dentistry. When compared to metal implant, it is more aesthetic, biocompatible, lighter material. It is a good alternative to titanium. Also, it exhibits less stress shielding and very limited osteoconductive property.⁶ Stress shielding refers to reduction in bone density as a result of removal of typical stress from the bone by an implant. Wolff's law states that your bone will adapt based on the stress or demand placed on them. Pure PEEK has elastic modulus of 3-4 GPa which is very low when compared to cortical bone. Young's modulus of elasticity for cortical bone is 14 GPa. Hence various reinforced PEEK composites are developed for e.g., Carbon-reinforced PEEK, Glass-fiber reinforced PEEK (GFR-PEEK), whose modulus of elasticity is close to human cortical bone. And it indicated the potential for more homogenous stress distribution to bone compared to titanium. The unwanted stress shielding phenomenon is prevented by this property of PEEK.⁷ Cytocompatibility is a very important factor when it comes to dental implant. A material should not be cytotoxic, it should be compatible to the cells. A good cytocompatibility implant material can form good bone bonding with the surrounding tissue. PEEK in its pure form or when untreated is a bioinert and hydrophobic material. But by introducing biologically active substances such as calcium hydroxyapatite HAp, titanium etc by surface coating or plasma spraying over PEEK, PEEK surface roughness and hydrophilicity can be increased. And that's why modified PEEK forms a better bond with bony tissues⁸. However, plasma spraying involves high temperature which can degenerate PEEK due to its low melting point. If thick calcium phosphate is coated over PEEK, it can chip off because of poor bond strength. Recently researchers have concluded that PEEK can be modified by blending or coating it with nano-sized particles and producing nano level surface modifications.⁴ PEEK do not show any allergic reaction and is a good alternative in case of titanium allergy. Pure or unfilled PEEK is beige- brown in color and is esthetically better than titanium as it does not show any grayness through the gingiva or tissue discoloration. Also, PEEK is a radiolucent material so it does not have any artifact in computer tomography and magnetic resonance tomography hence allow for better examination of post operative healing phase.⁹

PEEK AS AN ABUTMENT MATERIAL

An ideal abutment material is the material that meets all mechanical, biological and aesthetic expectations. Different materials such as titanium, zirconium, ceramic, peek etc. have been used for fabrication of implant abutment. Among this titanium is the most preferred material despite of its hypersensitivity and susceptibility to corrosion. Though in case where aesthetic is at high demand, no completely satisfactory result is found yet. Mostly aesthetic issue is found in case of thin gingival biotype. The titanium and its alloy change the color of marginal peri implant tissue and shows grayness through the gingiva.¹² Zirconia is also used in fabrication of an implant abutment because of its high compression strength and better aesthetics, but it also has lower tensile strength and fracture toughness as compared to

titanium and its alloy. Slowly after certain period of time abutment made of zirconia can be worn out intraorally. Also because of poor mechanical resistance it can cause changes in internal structures.⁵ Pure or untreated PEEK has shown to decrease stress-shielding around implant hence is used as a temporary or provisional abutment. Stress shielding refers to decrease in bone density as a consequence of elimination of typical stress from the bone by an implant. It is not used as a definitive abutment because of its lower fracture resistance. Although with the introduction of ceramic reinforced PEEK (Bio-HPP), it is possible to use PEEK as a definitive abutment.¹³ The mechanical property of PEEK and that of human cortical bone and dentin are very close, hence PEEK has less stress shielding effect. Also, higher mechanical property of PEEK makes it suitable for both abutment and prosthetic material. An abutment screw fabricated of modified PEEK material is better than traditional metal screw due to its similar elasticity. In case of implant screw breakage, screw fabricated of PEEK can be detached more easily. Acc. to Juvora (Juvora Ltd.) a manufacturer of PEEK, PEEK abutment screw needs to be tightened to a torque of 15Ncm and not above this limit as this will lead to plastic deformation of mesostructure of PEEK, which is mostly seen in case of titanium alloy.¹¹ Acc. to research if PEEK abutment is compared with zirconia, titanium, and ceramic abutment deformation can be seen in PEEK abutment rather than breakage whereas breakage in zirconia and metal abutment is found in holding screw and in ceramic abutment breakage is seen in abutment itself. PEEK is a semi crystalline structure which reduces fragility and hence deformation is seen other than breakage. In case of difficulties occurring in upper structures, PEEK abutment can be changed and problem with broken screw can be evaded.¹⁴

PEEK AS A FIXED PARTIAL FRAMEWORK

PEEK is beige brown in color which is esthetically unsuitable especially for anterior restoration. PEEK shows low half lucency which can be over coated with composite resin. Thus, PEEK is veneered with composite resin to improve its esthetic. The chief concern in achieving sufficient PEEK and composite bond strength is poor wetting ability of PEEK. Till date, air-born particle abrasion and etching is found to be a better way to improve the wetting ability of PEEK. Numerous experiments have been conducted to improve the bond between PEEK and composite. Different approaches were used because the traditional composite veneering applications were insufficient for PEEK. Sulfuric acid has been found to strengthen bonds in research using piranha solution and sulfuric acid. Known techniques to improve wettability include plasma treatment, etching, and airborne-particle abrasion.¹¹ Looking at the excellent mechanical properties, abrasion resistance and adequate bonding to composite and teeth, PEEK fixed partial denture is anticipated to have a satisfactory survival rate.³ In an in-vitro study PEEK 3-unit FPD showed excellent outcome. PEEK fixed partial denture manufactured by means of CAD-CAM have higher fracture resistance (2354N) compared to zirconia (981-1331N), alumina(851N) or lithium disilicate glass ceramic(950N). Masticatory load on teeth is about 400-500N. Thus, because of higher fracture resistance PEEK is good for producing framework.¹⁵ PEEK material is also easy to repair and do not wear off inside the oral cavity neither do they distort during processing. It is not soluble in water and also do not react with other materials. Thus, PEEK is a very good replacement for patients who are sensitive to metal alloys.¹²

PEEK AS A REMOVABLE PARTIAL FRAMEWORK

PEEK allow fabrication of light weight metal free RPD's and eliminate the esthetically unacceptable metal clasp, metallic taste and risk of allergies related to RPD. They have some favorable properties like excellent biocompatibility, good mechanical properties, good thermal properties, chemical resistance, beige brown color material which allow its use as a

framework for RPD and dental clasp.² Acc. to study done by Tannous et al despite of all the favorable properties of PEEK, PEEK clasp exhibits lower retentive forces than metal clasp. Though properly fabricated PEEK clasps with an undercut of 0.5mm or with increased bulkiness can provide sufficient retention. He also found that Co-Cr clasp shows higher retentive forces in the first period of cycle but decreases till the end of the cycle while PEEK clasps carries longer retention with comparatively lower retention than Co-Cr¹⁰. Modified PEEK i.e. BioHPP clasps are gentle to enamel and restorative materials. The fabrication of maxillary class I Kennedy classification removable partial denture (RPD) frameworks uses high performance polyether-etherketone (PEEK) polymer (BioHPP), which reduces strains and distal torque on abutment teeth. Additionally, it satisfies the patient's wish for RPDs devoid of metal and reduces the danger of oral galvanism. In the realm of dentistry, BioHPP is a workable biomaterial that enables the replacement of traditional polymers as well as metals, ceramics, and alloys.¹⁶ This newly modified material also have low plaque affinity, thus reduces the incidence of carious lesions and periodontal diseases. The color stability of PEEK is also found to be more stable than other material. Bio HPP can be considered as a good alternative material for abutments with decreased periodontal support when replacing distal extension situations.⁹

CONCLUSION

PEEK can be employed in various dental applications, including implants and fixed and removable prosthetics, thanks to its superior physical, mechanical, cosmetic, and biocompatibility qualities. Enhancing bioactivity while maintaining the material's characteristics is the main concern for PEEK as an implant material. PEEK's mechanical characteristics have been enhanced by carbon fiber reinforcement, making CFR-PEEK a more appealing substitute for metallic materials. When compared to other readily accessible biomaterials that have been in clinical use for many years, PEEK polymers are intrinsically strong, inert, and biocompatible. Neither the bulk material nor its particles evoke any detrimental biological reaction. Given that PEEK is still a new material; extensive clinical investigations are required before it can be used as a dental biomaterial.

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