A Review

Application of PEEK in Implant Dentistry: A Review

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Abstract

Background:Currently, innovative techniques and materials are being developed in the field of dentistry. While each has its benefits and drawbacks, the primary challenge is selecting the most suitable materials based on their mechanical, physical, and biochemical properties. As there is a growing demand for esthetics, metal-free materials are needed to meet this demand. Recently, Polyetheretherketone (PEEK), a member of the Polyaryletherketone (PAEK) family, has emerged as a promising alternative material for fixed dental prostheses due to its impressive mechanical properties. Additionally, PEEK and PEEK-based compounds may offer viable alternatives to titanium in the field of dental implantology due to their biocompatibility and high-performance properties.

Keywords: Implant dentistry, Polyetheretherketone (PEEK), PEEK implant.

Introduction

Dental implants are widely regarded as the optimal solution for restoring teeth in patients who are either completely or partially missing their teeth.[1] The success of dental implants over the long term is heavily reliant on minimizing the amount of bone loss that occurs around the implant when it is subjected to functional loads. In contemporary dental practice, titanium and its alloys, as well as zirconium, are the most commonly utilized materials for dental implants.[2] Some disadvantages of titanium and its alloys include metal ion release and subsequent osteolysis, metal corrosion and poor compatibility with modern imaging techniques[1,2]. To get around these restrictions and reduce biological issues that arise after implant placement, research has moved its focus to assessing titanium substitutes. Polyetheretherketone (PEEK), a partly crystalline poly aromatic linear thermoplastic material, is the most promising innovative substitute.[2,3] The materials from the Polyaryl-etherketone (PAEK) family belong to high-performancepolymers. They can be defined as materials that retain functionality even in extreme conditions,[3] Many uses for clinical dentistry have been investigated with PEEK. For instance, because PEEK and bone have more similar mechanical characteristics, PEEK dental implants have shown less stress shielding than titanium dental implants[4]. PEEK is a material that shows promise for both fixed and removable prosthesis, using post and core repair to reduce the likelihood of root fracture[5]. This article addresses the application of PEEK material in field of implant dentistry.

General characteristics of PEEK

Polyetheretherketone (PEEK) is a polycyclic, linear polyamide polymer. It was first developed in 1978 by a team of English researchers. Later, PEEK was commercially available for industrial uses. PEEK does not causes allergy. PEEK's mechanical properties remain unchanged during the sterilization process using steam, gamma rays and ethylene oxide. (Table 1) Polyether ether ketone has hydrolytic resistance, non-toxicity and one of the highest biocompatibility.[6]

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S.NO	PROPERTIES	VALUES
1	Tensile strength	90-100 Mpa
2	Flexural strength	140-170 Mpa
3	Young's modulus	3-4 Gpa
4	Density	1300 kg/m³
5	Thermal conductivity	0.29 W/mK
6	Specific gravity	(g/cm3) 1.31
7	Vitreous transition temperature	143 °C
8	Melting temperature	343 °C

Table 1. Properties of Peek

PEEK in Implant Dentistry

Wolff's Law states that bone will adapt to the mechanical loads under which it is placed. The biomechanical phenomena known as stress shielding results in adaptive changes in the strength and stiffness of the bone surrounding metallic implants. It also causes a decrease in the volume of bone surrounding an implant since the implant shields normal loads, which may eventually cause the implant to loosen.[7] Zirconia and titanium have elastic modulus of 110 and 210 GPa, respectively, which is 5–14 times higher than the elastic modulus of compact bone, which is 15 Gpa.

A titanium implant's gradient difference in elastic modulus from the surrounding bone can lead to stress at the implant-bone interface during load transfer, which can induce peri-implant bone loss.[8] We need a material with an elastic modulus that is near to bone in order to overcome this. Polyetheretherketone (PEEK) has an elastic modulus of 3.6 GPa,[7,8] which is closer to that of bone.

By reinforcing it with carbon fibers, for instance, its modulus can be changed to 18 GPa, which is more in line with cortical bone. [8]An further issue with titanium implants is their hypersensitivity and poor esthetics due to lack of light transmission. In situations when there is gingival recession surrounding a titanium implant or thin biotype mucosa, this may cause a dark shimmering of the periimplant soft tissue.[2,8] High-performance polymer PEEK has a white hue, a suitable biological response, and fracture resistance.

It melts at 343 °C and has a vitreous transition temperature of about 143 °C.[7] Except 98% sulfuric acid, it is extremely resistant to heat deterioration, aquatic environments, and harsh etching conditions.[1,7]

However, PEEK has extremely limited intrinsic osteoconductive characteristics compared to titanium. As a result, a great deal of research has been done to increase PEEK implant bioactivity.[4] PEEK dental implants have surface coatings of hydroxyapatite, barium sulfate, titanium oxide, or calcium phosphate.

These coatings have been topographically changed through the use of acid treatment and airborne-particle abrasion, which has increased osteoblastic activity and improved bone-to-implant contact (BIC).[7] It has been demonstrated that treating PEEK with sulfuric acid ($H2SO_4$) increases its surface bioactivity and results in the creation of sulfonated porous layers. This process is easy to use, efficient, and doesn't significantly harm the material's mechanical qualities.[9] Graphene oxide enhances hydrophilicity, microroughness, nanostructure, and osteogenesis. Furthermore, it neither produces systemic toxicity nor is cytotoxic.

They say it's a good[10] BioHPP (Bredent GmbH Senden, Germany) is a modified PEEK that contains 20% ceramic fillers and is non-allergic. and is quite biocompatible. High-quality prosthetic restorations may be produced because of BioHPP's exceptional stability, great ideal polishable characteristics, and aesthetically pleasing white tone.[6]

The BioHPP frameworks broke with a compressive strength that was less than group Ti's, at a mean load of 1518 ±134 N. Still, the value remained more than the 600–920 N stated maximum molar masticatory force. This implied that the fracture resistance of the veneered BioHPP FDPs was suitable for employment in the future. It's possible that increasing the connector's surface area raised the fracture load.[11]

The polymer's bond strength to other materials, as the structure must be able to be coated with all common coating composites. Evaluating this material's bond strength about the Cr-Co alloy and metal-ceramic, as well as that of its modified version (BioHPP), leading to improved PEEK material adherence.

PEEK as an Implant Abutment

PEEK implant abutments are regarded as an alternative material even if they do not have the necessary biomechanical characteristics to completely replace the titanium abutment. Temporary abutments made of PEEK can be employed, particularly in the anterior region where reduced masticatory forces are present. [9] Because PEEK breaks before the implant or internal screw, it serves as a "sacrificial material" absorbing all plastic deformation. On the other hand, as it Follows overloading, the implant's viability is compromised by the plastic deformation of titanium abutments, which is localized in the internal connection. The titanium abutments outperformed the PEEK abutments in terms of maximal mechanical performance, according to uniaxial compression testing.[7]

The loss of torque and microleakage were measured using methylene blue. For titanium abutments, the torque loss was around 10%, whereas PEEK demonstrated a far higher torque loss of up to 50% (P<.001). [7]

Limitation of PEEK

PEEK implant abutments don't meet the biomechanical requirements of titanium definitive abutments in terms of torque loss and microleakage. Nonetheless, the PEEK abutments could withstand light stresses for 1.2 million cycles, or five years of masticatory activity, without reaching 140 N.

PEEK abutments have several drawbacks, such as a greater vertical displacement than titanium abutments and plastic deformation at the abutment-implant interface, which can result in substantial torque loss and microleakage. PEEK abutments may be appropriate as temporary abutments, particularly in the anterior region and for patients without parafunction. Nevertheless, torque loss and microleakage concerns need to be taken into account. [7]

Conclusion

PEEK is a stylish contemporary material that can be used in prosthodontics. It is utilized to create both fixed and detachable prostheses because of its advantageous chemical, mechanical, and physical qualities. Out of all the features of PEEK, the one that is advantageous for its application in implant-based prostheses is that it has a low elastic modulus, comparable to bone. PEEK abutments might be utilized as anterior interim abutments.

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