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Peek in dental implant- A review of literature

Bharath Kumar K* and Sasikala Ramajayam

Department of Prosthodontics, Vinayaka Mission's Sankarachariyar Dental College, Vinayaka Mission's Research Foundation (Deemed to be University), Salem, Tamil Nadu, P.O: 636308, India.

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Abstract

Polyether ether ketone (PEEK) is an important material which is used in several dental field like oral implantology, prosthodontic, orthodontic dentistry for dental implants, abutments, healing caps, orthodontic braces, and most importantly denture prosthetic framework. The best mechanical property of PEEK is that it overcomes the disadvantage of titanium implants i.e., aesthetic and allergic reaction. The aim of this article is to mainly focus on the surface modification of PEEK implant material to make it a better version of dental implant so that it overcomes the bioactivity and bone-integrity of the implant then the fabrication, structure, properties, and application, surface topographical modification and bioactive PEEK composites are described.

Keywords: Polyether ether ketone (PEEK); Carbon fibre reinforced -polyether ether ketone (CFR-PEEK); PEEK Implants; PEEK/G; PEEK/FT

1. Introduction

PEEK composites are biocompatible materials that may overcome the esthetic and allergic problems of titanium dental implants. However, their potential for osseointegration with subsequent survival rate is still questionable [1].

In 1978, a group of English scientists developed PEEK, a semi crystalline linear polycyclic aromatic thermoplastic. The industrial applications in the manufacture of aircrafts, turbine blades, piston parts, cable insulation, bearings and compressor plate valves, were commercialized in 1980s. In Orthopedics and spinal implants, PEEK has become an important alternative for metal implant components [2]. PEEK is a radiolucent material that is chemically and physically stable and resistant to radiation damage. It is also wear-resistant, compatible with many reinforcing agents (such as glass and carbon fibres), stable at temperature exceeding 300°C. This polymer is very biocompatible in vivo and in vitro, does not cause toxic or mutagenic effects; therefore, it is indicative in patients allergic to titanium. The allergic symptoms are angioedema, itching, swelling of the tongue, and skin thickening [3].

2. Material and methods

The database for this article has been taken from various electronic search which is Research Gate, WILEY-VCH, Hindiawi, Frontiers, Elsevier, Meridian Allen press, Tylor and Francis, MDPI obtained via google scholar from 2014-2021 using the keywords, PEEK, Surface modification in dental implant.

* Corresponding author: Bharath kumar k
Department of Prosthodontics, Vinayaka Mission's Sankarachariyar dental college, Vinayaka Mission's Research Foundation (Deemed to be University), Salem, Tamil Nadu, P.O: 636308, India.

2.1. Structure, properties, application in PEEK

2.1.1. Structure

PEEK is thermoplastic, monochromatic, semi crystalline polymer [4]. It is a member of Polyaryletherketone (PAEK) family which is colourless organic thermoplastic polymer. It is a single monomer so it is homopolymer which is semi crystalline thermoplastic were retained even at high temperature with exceptional chemical and mechanical properties. The process of making PEEK implant components is very easy because of length, chemical composition; structure renders it stable at high temperature. The structure of PEEK is repeated aromatic ring of the ether and ketone group [5].

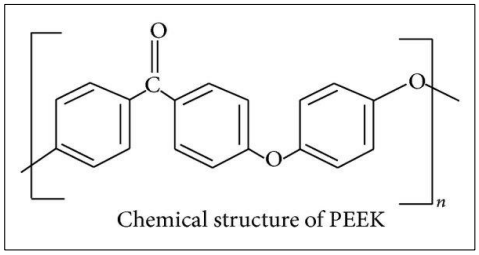

Figure 1 Chemical structure of PEEK

PEEK is used in the field of orthopaedics, spinal and dental prostheses. It has been used in implant dentistry which includes dental implants, temporary abutments, implant supported provisional crowns fixed prostheses, removable denture frameworks, and finger prostheses [4].

2.1.2. Properties

PEEK has good aesthetics and mechanical properties, similar to human bone, PEEK materials are at risk of fracture and abrasion [4]. PEEK is radiolucent material which are chemically and physically stable and resistant to radiation damage. PEEK is compatible with glass and carbon (reinforcing agents) which are stable at temperature exceeding 300°C. PEEK does not cause any toxic or mutagenic effect because this polymer is more biocompatible in both in vivo and invitro, therefore it is an ideal alternative material to patient who are allergic to titanium implant.

The mechanical properties of PEEK have an elastic modulus of 3-4GPa which is similar to the human cortical bone are very potential for more homogenous stress distribution to the supporting tissue.

The bone-to-implant contact (BIC)need to be improved, this are improved by the two methods one involves surface modification and another is composite preparation.

2.1.3. Dental application [2]

PEEK is a biocompatible and has a natural tooth colored appearance, which is widely used in implant dentistry. This PEEK has an alternative to orthodontic wires for reasons of improved aesthetics, allergic to metals. PEEK can easily shape with dental burs, though it has low translucent and greyish pigmentation, it requires veneering.

2.1.4. Surface modification

To make PEEK more bioactive there are different types of surface modification, surface modification aims to alter the surface of PEEK with little or no effect on the core with production of nanocomposite of PEEK.[7][8]

PEEK can be modified by two treatments:

- Chemical Treatment
- Physical treatment

By physical treatment PEEK can be modified by plasma modification such as nitrogen and oxygen plasma, ammonia/argon plasma, oxygen plasma, ammonia plasma, oxygen and argon plasma, and hydrogen/argon plasma and accelerated neutral atom beam (ANAB).

This modification is used to increase adhesion, proliferation, and osteogenic differentiation so plasma modification has long been used to modify PEEK.

ANAB has been shown in invitro experiments to enhance the growth of human fetal osteoblast cells and increase osteointegration.

The number of materials used for surface coating such as titanium, gold, titanium dioxide, diamond like carbon, tert-burtoxides and hydroxyapatite (HA) due to biocompatibility, bioactivity, and osteoconductivity in vivo these materials are widely used by the recent days. The techniques for surface coating are aerosol deposition, vacuum plasma spraying, arc ion plating, ionic plasma deposition, plasma immersion ion implantation and deposition, physical vapour deposition, radio frequency magnetron sputtering, cold spray technique, electron beam deposition and spin coating.

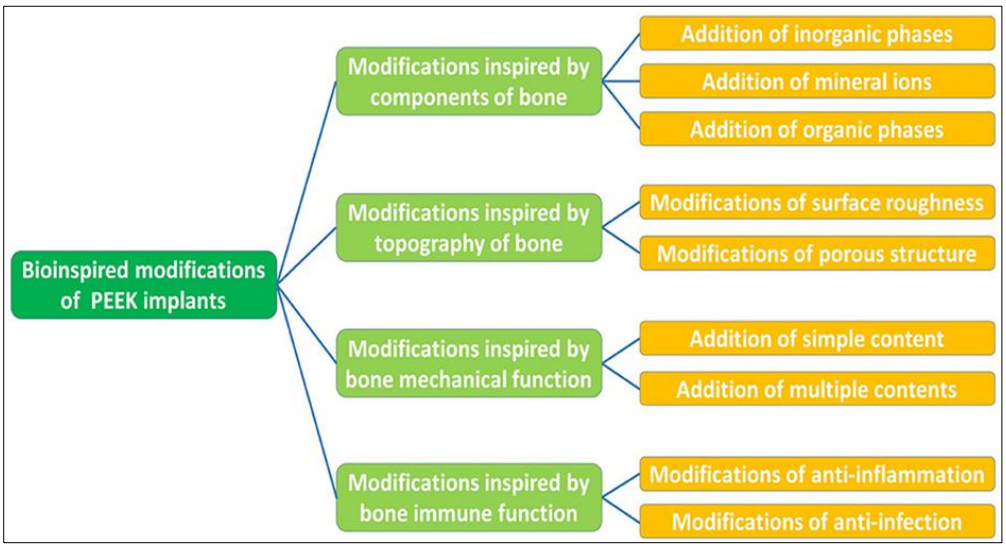

Figure 2 Bioinspired modifications of PEEK implants

There are many ways in which PEEK can be modified at a nanometer level to overcome its limited bioactivity. Nanoparticles such as TiO_2, HAF, and HAP can be combined with PEEK through the process of melt-blending to produce bioactive nanocomposites. In comparison with pure PEEK composites have superior tensile properties.

2.1.5. Surface topographical modifications [9]:

Table 1 Surface topographical modifications

Surface Modifications	**Procedures**	**Material**
Coating	Plasma spraying	Hydroxyapatite (HA), Titanium (Ti)
	Spin coating	Nano sized HA crystals containing surfactants, organic solvent, an aqueous solution of $Ca(NO_3)_2$ and H_3PO_4
	Electron-beam evaporation (EBE)	Ti; Silicate
	Plasma immersion ion implantation (P^{III})	Titanium dioxide (TiO_2); calcium (Ca); water (H_2O); Argon (Ar)
Surface topographical modifications	Acid etching	Sulfuric acid
	Sandblasting	TiO_2, alumina (Al_2O_3)
Chemical modifications	Sulphation	Sulfonate groups ($–SO_3–$)
	Amination	Amine functions

	Nitration	Nitrate functions
Incorporating with bioactive properties	Bioactive inorganic materials	Nano-TiO_2(n-TiO_2); nano-fluorohydroxyapatite (n-FHA)
Improving hydrophilicity	UV irradiation	UV-A light, UV-C light
	Plasma gas treatment	Oxygen plasma

2.2. Biocompatibility of PEEK

Biocompatibility of PEEK is reported in three papers [2]:

- Showed no evidence of cell damage caused by PEEK.
- Described the clinical evidence of allergy to PEEK, in which the removal of the implant increases the patient's allergic symptoms.
- PEEK implant led to poor osseointegration and subsequent infections and implant Koss.

2.3. Fabrication of PEEK [3]

The two forms of PEEK/G AND PEEK/FT nanocomposite were fabricated using melt bending and compression molding techniques. PEEK a powder and bioactive nanofillers were dried overnight in a vacuum oven at 120°C for fabrication process to complete removal of moisture.

2.4. Bioactive peek composites [8]

The bioactivity of PEEK is increased by compounding with bioactive material, there are many bioactive materials such as HA, and strontium containing hydroxyapatite, TiO_2, βTCP, and bioactive glass was compound with PEEK for increasing the bioactivity of PEEK.

By in vivo study of composite with 20 vol% of HA show the present of fibroblast cell which stimulate vascularization. This study showed the formation of osteoid and osteocytes within lamellar bone in developing mature bone at longer implantation periods.

In vivo study of laser sintered PEEK/βTCP implant revealed better interaction with surrounding bone and direct connection to the surrounding bone comparison with pure PEEK [8].

3. Conclusion

This article reviewed the structure and properties of dental implant and available surface modification of dental implant. To overcome the limited bioactivity, TiO_2, HAF, and Hap can be combined with peek by the process of melt-bending to produce bioactivity of peek. The modified peek shows more tensile properties when compared to pure peek.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest.

References

[1] Elawadly T, Radi IA, El Khadem A, Osman RB. Can PEEK be an implant material? Evaluation of surface topography and wettability of filled versus unfilled PEEK with different surface roughness. Journal of Oral Implantology. 2017 Dec, 43(6):456-61.

[2] Ortega-Martínez J, Farré-Lladós M, Cano-Batalla J, Cabratosa-Termes J. Polyetheretherketone (PEEK) as a medical and dental material. A literature review. Medical Research Archives. 2017 Apr 15, 5(4)

[3] Taymour N, Fahmy AE, Gepreel MA, Kandil S, El-Fattah AA. Improved Mechanical Properties and Bioactivity of Silicate Based Bioceramics Reinforced Poly (ether-ether-ketone) Nanocomposites for Prosthetic Dental Implantology. Polymers. 2022 Apr 18, 14(8):163

[4] Suphangul S, Rokaya D, Kanchanasobhana C, Rungsiyakull P, Chaijareenont P. PEEK Biomaterial in Long-Term Provisional Implant Restorations: A Review. Journal of Functional Biomaterials. 2022 Mar 22, 13(2):33.

[5] BENAKATTI VB, SAJJANAR JA, ACHARYA A. Polyetheretherketone (PEEK) in Dentistry. Journal of Clinical & Diagnostic Research. 2019 Aug 1, 13(8)

[6] Gu X, Sun X, Sun Y, Wang J, Liu Y, Yu K, Wang Y, Zhou Y. Bioinspired modifications of PEEK implants for bone tissue engineering. Frontiers in bioengineering and biotechnology. 2021 Jan 12, 8:631616.

[7] Rahmitasari F, Ishida Y, Kurahashi K, Matsuda T, Watanabe M, Ichikawa T. PEEK with reinforced materials and modifications for dental implant applications. Dentistry journal. 2017 Dec 15, 5(4):35

[8] Almasi D, Iqbal N, Sadeghi M, Sudin I, Abdul Kadir MR, Kamarul T. Preparation methods for improving PEEK's bioactivity for orthopedic and dental application: a review. International journal of biomaterials. 2016 Apr 4;2016.