International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 11 Issue 10 ǁ October 2023 ǁ PP. 373-375

PEEK Dental Implant - A Narrative Review

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Abstract: *Dental implants are synthetic structures that are surgically placed in the jawbone to support dental prostheses. An implant, a custom-made tooth, and an abutment make up this structure. Two commonly used materials in dental implants are zirconia and titanium, both of which have flaws, such as dispersed radiation, peri-implants-related surface degradation and contamination, and sporadic metal sensitivities and allergies. The development of PEEK dental implants aims to address these issues. Polyether ether ketone (PEEK) is a chemically and physically stable radiolucent substance that is resistant to radiation damage. It is wear-resistant, stable at temperatures above 300°C, and compatible with a variety of reinforcing materials, such as glass and carbon fibres. Additionally, in vitro and in vivo, this polymer is highly biocompatible and has no mutagenic or toxic effects.*

Keywords: *PEEK, Dental Implants, titanium, zirconium, carbon fibres*

Date of Submission: 18-10-2023 Date of acceptance: 02-11-2023

I. Introduction:

A dental prosthesis can be either permanent or removable, and it is held in place by a dental implant. The implant is a structure made of materials that are inserted into the oral tissues below the mucosa and/or periosteum, either within or through the bone. Typically, titanium (Ti) and its alloys are used for implant components, but they can cause limitations such as inducing allergy and black discoloration in the anterior zone [1], [2].

PEEK is a thermoplastic material that possesses a semi-crystalline structure. It was first developed by a group of British scientists back in 1978. PEEK composites are known to be biocompatible substances that could potentially address the cosmetic and allergenic concerns associated with titanium dental implants. However, it is still uncertain whether they can effectively osseointegrate and achieve a high success rate [3].

PEEK is a radiolucent material that can withstand radiation and is chemically and physically stable.. It is also resistant to wear and suitable for a variety of reinforcing materials, including glass and carbon fibres. Additionally, it is durable at temperatures higher than 300 °C. This polymer is exceedingly biocompatible both in vivo and in vitro, and it has no mutagenic or toxic consequences, making it useful for people who are allergic to titanium. Symptoms of allergy include angioedema, itching, tongue swelling, and skin itching [4].

Structure of PEEK:

The PEAK family's most crucial member is PEEK, a semicrystalline polymer made of repeating aromatic rings from ether and ketone groups [5][6].

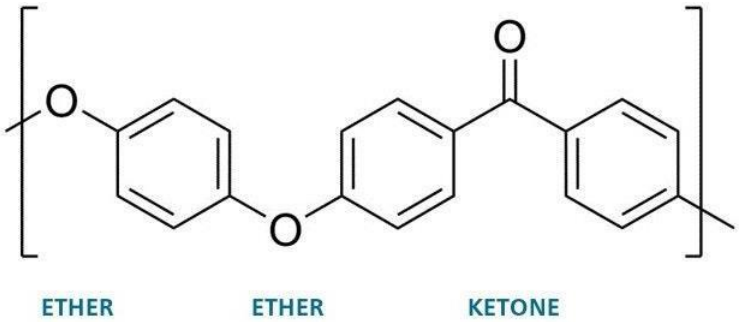

Figure 1: Structure of polyetheretherketone (PEEK); Courtesy: Victrex

Properties of PEEK:

- *Chemical and physical properties:*

PEEK is a highly resilient material that can endure extreme temperatures and hydrolysis without any damage. Its semi-crystalline structure provides remarkable resistance against sterilization methods [7]. PEEK is unique in that it has a low elasticity modulus, similar to that of bones, at

3.6 GPa. This characteristic helps in preventing bone resorption and facilitating optimal bone remodelling. To enhance the elasticity modulus for applications requiring more rigidity, carbon fibres can be added to increase the PEEK modulus to as high as 18 GPa. This addition makes the material even more impervious to mechanical, chemical, and thermal stress [8].

- *Biological properties:*

After conducting extensive testing, it has been concluded that PEEK is a safe material that does not present any risks of cytotoxicity, mutagenicity, carcinogenicity, or immunogenicity in its toxic state [9]. The modified version of PEEK, called Bio-HPP (High-Performance Polymer), has been further improved with nanotechnology, making it even more impressive. It has excellent polishing capabilities, minimal plaque attraction, and remarkable durability [10].

- *Aesthetic properties:*

Using PEEK for monolithic aesthetic restorations on anterior teeth is not recommended due to its greyish-brown color. Instead of solely relying on it as an implant and framework material, it is suggested to use more aesthetic materials like composite as a coating to enhance the aesthetics when used as direct or indirect restorative materials [11].

Applications of PEEK:

- PEEK is a material commonly used in dental, spinal, and orthopaedic prosthetics. It has also been used in implant dentistry, including dental implants, provisional crowns supported by implants used as temporary abutments, fixed prosthetics, frameworks for removable dentures, and finger prosthetics [12].

PEEK is a commonly used material in implant dentistry due to its biocompatibility and tooth-like appearance. It serves as an alternative to orthodontic wires and is particularly useful for individuals with metal allergies. However, PEEK's low translucency and greyish color require it to be veneered for improved aesthetics. Dental burs can easily shape PEEK. [13]

Modifications of PEEK:

There are various surface modifications that can be used to increase PEEK's bioactivity [14][15]. Surface modifications are intended to change PEEK's surface while having littleto no impact on the material's core.

PEEK can be modified by 2 treatments:

1. Chemical treatment
2. Physical treatment

It is possible to modify PEEK through plasma alteration, using techniques such as accelerated neutral atom beams, nitrogen and oxygen plasma, and ammonia/argon plasma. This method has been employed to enhance adhesion, proliferation, and osteogenic differentiation. Studies have shown that ANAB can improve osseointegration and the development of human fetal osteoblast cells in vitro [3].

There are several techniques that can be used to coat the surface of PEEK, such as aerosol deposition, vacuum plasma spraying, arc ion plating, ionic plasma deposition, plasma immersion ion implantation and deposition, physical vapour deposition, radiofrequency magnetron sputtering, cold spray technique, electron beam deposition, and spin coating. At the nanoscale level, PEEK can also be modified in various ways to increase its bioactivity. One approach is to use melt blending to combine nanoparticles like TiO2, HAF, and HAP with PEEK, resulting in the creation of bioactive nanocomposites [3].

Bioactivity of PEEK:

A method of enhancing the bioactivity of PEEK involves combining it with bioactive materials such as bioactive glass, HA, strontium-containing hydroxyapatite, TiO2, and ßTCP. The resulting laser-sintered PEEK/ßTCP implant exhibited a stronger connection with the surrounding bone and a more direct attachment to it, as compared to pure PEEK. This was observed in a study where different bioactive materials were tested for their effects on PEEK. [15].

Advantages of PEEK:

- Flexibility is a major benefit of PEEK material
- PEEK has strong radiolucency, making it opaque to radio waves.
- Aesthetic
- Thermal resistance
- Cost-efficient [16].

II. Conclusion:

When it comes to implant dentistry, PEEK is a versatile material that can be used for both temporary and long-term provisional restorations. It has aesthetic and mechanical properties that are similar to human bone, but it is prone to fracture and abrasion. On the other hand, PEEK has been shown to promote bone remodelling, making it a better choice for abutment structures than titanium. However, more research is needed to determine whether PEEK can fully replacetitanium in long-term restorations.

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