Original Article

THE SCOPE OF PEEK IN DENTAL IMPLANTOLOGY: LITERATURE REVIEW

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Abstract

The search for an ideal restorative material to replace lost dentofacial structures has led to the development of a new promising polymeric material, Polyetheretherketone. Due to its superior biocompatibility, chemical stability, fatigue resistance, strength, stiffness, toughness, and radiolucency, PEEK is an appealing alternative to conventional materials in the field of prosthetic dentistry. This article aims to encapsulate the precedence of PEEK in implantology, compared to other restorative materials that have been used currently, based on various studies conducted on this material.

Introduction

In the realm of implantology, titanium has traditionally been the preferred material for dental implants. The endosseous implants initially developed by Branemark were made of pure titanium and alloys like Ti-6Al-7Nb and Ti-6Al-4V. Their superior mechanical qualities, increased corrosion resistance, strong biocompatibility, and passivation make titanium and its alloys the material of choice. (1,2)

Few instances of potential hypersensitivity to titanium have been documented in the literature. Another problem is the differential elastic modulus between a titanium implant and the surrounding bone, which may lead to stress at the implant-bone interface during load transfer, most likely leading to peri-implant bone loss. This phenomenon is referred to as stress shielding, causing long-term implant failure. In cases with thin biotype mucosa, mucosal recession surrounding a titanium implant, or high smile line cases, titanium can produce aesthetic issues because of its lack of light transmission, which results in a dark shimmer of the peri-implant soft tissue. (3,4)

The growing demands for metal-free materials in dentistry, together with the increased sensitivity and allergies, have promoted advancements in material science. As a substitute for titanium, ceramic implants made from aluminum oxide were suggested about 40 years ago. However, this material was unable to meet the standards due to the high fracture incidence. Due to its tooth-like appearance, mechanical qualities, biocompatibility, and low plaque affinity, zirconia ceramic dental implants are currently seen to be a more advantageous alternative. According to reports, zirconia implants have a larger stress distribution surrounding them than titanium implants, which may be attributed to the material's higher elastic modulus of 210 GPa.(5,6)

Discussion

Recently, Polyetheretherketone (PEEK), a high-performance thermoplastic polymer belonging to the Polyaryletherketone family, was introduced to the market. Its biocompatibility, hydrophobicity, and low plaque affinity close to the dental structure have made great inroads in the field of prosthodontics. PEEK has high mechanical strength and is chemically stable at elevated temperatures with a melting point of 343 °C. Its thermal degradation occurs at temperatures between the glass transition and melt transition (143-343°C). PEEK is inert and resistant to deterioration during sterilization processes using steam, gamma, and ethylene oxide due to its resistance to radiations, particularly gamma and electron beam radiation, and chemicals other than concentrated sulfuric acid. PEEK having an elastic modulus close to human cortical bone makes a great alternative to titanium and other metals in the field of dental implantology and traumatology. (7,8)

Not just its physiological properties, but its high esthetic properties such as proximity to natural teeth color, radiolucency, rigidness, and light weightness make it the perfect choice for dental restorations. PEEK is used widely in CAD–CAM manufacturing for dental implants, provisional abutments, implant-supported removable prostheses, and fixed dental prostheses. (8–10)

Peek as dental implants

Various studies have been conducted to check the reliability of PEEK as an implant biomaterial. PEEK outweighs titanium's application in terms of less stress shielding, fewer hypersensitive and allergic reactions, better wear and abrasion resistance, low friction coefficient, and shock absorption effect. Invibio (formerly Victrex) is a pioneer in the manufacturer of medical-grade PEEK. PEEK-OPTIMA was introduced for an implant in 1999. (11)

In respect of the success of osteointegration, some studies that compared PEEK with conventional implant materials reported no significant difference. On the contrary other studies have shown PEEK exhibits extremely limited osteoconductive properties, unlike titanium. Therefore, extensive research has been performed to increase the bioactivity of PEEK implants. (1,12)

Methods to improve osseointegration are broadly divided into composite preparation & surface modifications. Composites preparation can improve osseointegration by incorporating bioactive nanoparticles such as hydroxy apaptite in the PEEK matrix using melt blending and compression techniques. However, this may deteriorate the mechanical properties of PEEK, potentially shortening the implant's lifetime. On the other hand, surface modifications, leave the bulk mechanical properties intact and alter only the properties of the surface to improve interactions with the surrounding tissue. Surface modification is further divided into physical treatment, deposition techniques, and wet chemical techniques. Physical treatments like chemical modifications, roughening, and patterning, allow for a fast change of the surface properties, but this method is difficult to apply to implants with complex shapes & requires expensive equipment. Another strategy is deposition techniques of organic or inorganic substances on the surface. To produce such bioactive coatings, methods such as cold spray technique, spin coating techniques, aerosol deposition, ionic plasma deposition, plasma immersion ion implantation and deposition, electron beam deposition, vacuum plasma spraying, microwave-assisted coating processes, or wet chemical precipitation have been deployed. Wet chemistry techniques work by immersion of the PEEK material into a reaction solution, thus overcoming the problem of an incomplete coating of the implant surface.(9,13,14)

Nevertheless, the vast majority of the data available on the in vivo behavior of biocompatible dental implants is based on studies involving titanium-derived implants. Very little is known about the long-term results and the complications. (2)

PEEK as healing abutments

Considering adequate biocompatibility, PEEK healing abutments show no significant difference in bone resorption and soft tissue inflammation than titanium abutments. Thus, PEEK CAD-CAM healing abutments have been manufactured for extraoral prostheses like auricular prostheses. (15)

PEEK as abutments

PEEK abutment shows lower biofilm formation on its surface than the traditional abutment materials and promotes the bone remodeling process. They are suitable for long-term interim restorations, especially in the anterior area. Large vertical displacement, plastic deformation, high torque loss, microleakage, and lower fracture resistance are its limitations. More research is needed to use it as an abutment material. (1,16)

When compared to zirconium abutments, there was no fracture in the zirconium abutments whereas there was deformation but no breakage in the PEEK abutments. Breakage is seen in the holding screws rather than the abutment itself in metal and zirconium abutments and in the abutment itself in ceramic abutments. Due to PEEK's semi-crystalline structure, which lowers fragility, deformation is observed rather than fracture. As a result, PEEK abutments may be changed simply when needed avoiding the challenge to remove a broken screw, which is often encountered with titanium abutments. (17,18)

PEEK as abutment screw

PEEK and 30% CFR-PEEK abutment screws exhibited lower fracture resistance than titanium. The feasibility of PEEK as an abutment screw remains questionable and requires further testing. (16,19)

PEEK as implant-supported prosthesis

Due to the proven biocompatible nature and shock-absorbing characteristics of PEEK, while maintaining the possibility of CAD/CAM manufacture, PEEK as a material could be interesting for use in implant-supported restorations as a non-metal alternative. Material selection is extremely important for any implant-supported prostheses. PEEK framework having reduced weight, lower flexural strength and modulus of elasticity, and high bond strength to composite resins seem to be advantageous. However, increased minimum connector, greyish color, skill need, and higher cost than that for metal-ceramic or metal-acrylic resin restorations make its application troublesome. More clinical studies are needed before the use of PEEK as framework material in routine dental practices. (20,21)

Conclusion

Due to its superior mechanical, biological, and esthetic properties, PEEK seems to be a promising alternative to titanium and its alloys. Surface modifications of PEEK enhance the cell adhesion, proliferation, osteogenic potential, and thus osseointegration making it a viable implant biomaterial. Still further in vivo research is needed to validate if PEEK can eventually replace titanium implants in the future.

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