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Review Article

Polyetheretherketone (PEEK) in Implant Dentistry: From Biological Properties to Clinical Applications: A Mini Review

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Abstract

Polyetheretherketone (PEEK) has emerged as a promising biomaterial in implant dentistry due to its favorable mechanical properties, biocompatibility, chemical stability, and esthetic appearance. Originally introduced in orthopedic applications, PEEK has gained increasing attention as an alternative to conventional metallic materials in implant-related treatments. Its elastic modulus is closer to that of cortical bone than titanium, potentially improving stress distribution around implant-supported restorations. In addition, its radiolucency, reduced plaque accumulation and compatibility with CAD/CAM technologies have expanded its clinical applications. Recent studies have reported encouraging outcomes regarding soft tissue response, bacterial adhesion, and the use of PEEK in healing abutments, provisional restorations and implant-supported prostheses. However, the bioinert nature of untreated PEEK remains a challenge, necessitating the development of surface modification strategies to enhance tissue integration. The purpose of this mini review is to highlight recent evidence regarding material characteristics, biological properties, microbial interactions, and clinical applications of PEEK in implant dentistry, while discussing current limitations and future research directions.

Keywords: PEEK; Polyetheretherketone; Dental Implants; Healing Abutments; Peri-implant Soft Tissue

Abbreviations

PEEK: Polyetheretherketone; CAD/CAM: Computer-Aided Design/Computer-Aided Manufacturing; Ti: Titanium.

Introduction

Dental implants have become a predictable and widely accepted treatment modality for the rehabilitation of partially and completely edentulous patients [1]. Long-term implant success depends not only on successful osseointegration but also on the maintenance of healthy peri-implant hard and soft tissues [2,3]. Consequently, considerable attention has been directed toward the development of biomaterials that can optimize biological response while meeting functional and esthetic demands.

Titanium has traditionally been considered the gold standard material for implant components because of its excellent mechanical properties, corrosion resistance, demonstrated long-

term clinical success. However, certain limitations, including its metallic appearance and elastic modulus considerably higher than that of cortical bone, have encouraged the search for alternative biomaterials that may provide additional biological and esthetic advantages [4,5].

Polyetheretherketone (PEEK) is a high-performance thermoplastic polymer that has gained increasing interest in dentistry over the past decade. Originally introduced for orthopedic and spinal applications, PEEK possesses several favorable characteristics, including biocompatibility, chemical stability, radiolucency, low density and an elastic modulus closer to that of cortical bone than titanium [6,7]. In addition, the development of computer-aided design and computer-aided manufacturing (CAD/CAM) technologies has facilitated the fabrication of customized PEEK-based dental components with high precision and efficiency [8].

Recent studies have explored the application of PEEK in implant dentistry, particularly in healing abutments, provisional restorations, and implant-supported prostheses. Furthermore, growing evidence suggests that PEEK may exhibit favorable soft tissue responses and acceptable resistance to bacterial colonization, making it a promising material for peri-implant applications [9]. In light of the increasing interest in PEEK-based implant components, a comprehensive understanding of their biological behavior and clinical applications is essential. Therefore, this mini review aims to summarize the existing literature on the biological behavior and clinical use of PEEK in implant dentistry, with emphasis on its advantages, limitations, and future directions.

Material characteristics of PEEK

Polyetheretherketone (PEEK) is a semi-crystalline high-performance thermoplastic polymer belonging to the polyaryletherketone (PAEK) family. Since its introduction in orthopedic medicine, PEEK has gained considerable attention in dentistry owing to its favorable mechanical and physicochemical properties. The material demonstrates excellent chemical stability, high resistance to wear and remarkable durability in the oral environment [6].

One of the most important characteristics of PEEK is its elastic modulus, which ranges from approximately 3–4 GPa in its unmodified form and is closer to that of cortical bone compared with titanium. This property may contribute to a more favorable distribution of occlusal forces and reduce stress concentration around implant-supported restorations. In addition, PEEK demonstrates high fracture resistance and adequate mechanical strength for various dental applications [7,10].

Another significant advantage of PEEK is its radiolucency, which allows improved radiographic evaluation of surrounding tissues without imaging artifacts commonly associated with metallic materials. Furthermore, its low density contributes to the fabrication of lightweight prosthetic components while maintaining satisfactory mechanical performance [10].

From an esthetic perspective, PEEK exhibits a tooth-colored appearance that may provide advantages in situations with high esthetic demands or thin peri-implant soft tissues. Moreover, the material is compatible with CAD/CAM technologies, allowing the fabrication of customized dental components with high precision and reproducibility [8].

Biological properties and tissue response

Biocompatibility is one of the most important characteristics of any material used in implant dentistry. An ideal biomaterial should support cellular viability, promote tissue healing, and minimize adverse inflammatory reactions. Numerous studies have demonstrated that PEEK possesses favorable biocompatibility and can be safely used in various dental and medical applications [11].

The interaction between peri-implant soft tissues and transmucosal implant components plays a critical role in maintaining peri-implant health. Human gingival fibroblasts and epithelial cells have been shown to exhibit satisfactory viability and proliferation on PEEK surfaces. These findings suggest that PEEK can support soft tissue healing and contribute to the establishment of a stable peri-implant mucosal seal, which is essential for protecting the underlying implant from bacterial invasion [12-14].

In addition to its compatibility with soft tissues, PEEK demonstrates a low inflammatory potential. Several investigations have reported reduced expression of pro-inflammatory mediators and favorable tissue responses around PEEK surfaces. Such characteristics may contribute to improved wound healing and enhanced peri-implant tissue stability during the healing phase [15-17].

Despite these advantages, unmodified PEEK is considered a bioinert material. Unlike titanium, which naturally forms a biologically active oxide layer, PEEK exhibits limited surface bioactivity and reduced cellular attachment. Consequently, researchers have explored various surface modification techniques to improve its biological performance. These modifications include plasma treatment, laser surface treatment, sandblasting, sulfonation, and the incorporation of bioactive materials such as hydroxyapatite and titanium dioxide nanoparticles [11,18,19].

Surface modification has been shown to improve surface roughness, wettability, and protein adsorption, thereby enhancing cellular attachment and proliferation. Several studies have reported improved fibroblast and osteoblast responses following modification of PEEK surfaces, suggesting that these approaches may further optimize their performance in implant-related applications [18].

PEEK and bacterial adhesion

Bacterial colonization of implant-related surfaces is a key factor in the development of peri-implant diseases. Following exposure to the oral environment, implant components rapidly become coated with salivary proteins, facilitating bacterial attachment and biofilm formation. Persistent biofilm accumulation may lead to peri-implant mucositis and, if left untreated, peri-implantitis, ultimately compromising implant survival. Therefore, the interaction between implant materials and oral microorganisms is of considerable clinical importance [14,20].

Several surface characteristics, including roughness, surface energy, wettability, and chemical composition, influence bacterial adhesion. Consequently, numerous studies have investigated the microbial behavior of PEEK in comparison with conventional implant materials, particularly titanium. Current evidence suggests that PEEK exhibits bacterial adhesion comparable to or, in some cases, lower than that observed on titanium surfaces [14].

In addition to bacterial adhesion, the composition and complexity of the biofilm are important determinants of peri-implant health. Some investigations have demonstrated reduced biofilm biomass and lower bacterial counts on PEEK surfaces compared with conventional metallic materials. These findings have generated interest in the use of PEEK for transmucosal implant components, particularly healing abutments and provisional restorations, where plaque control is critical during tissue healing [21].

Clinical applications in implant dentistry

The favorable mechanical properties, biocompatibility, and compatibility with digital manufacturing technologies have expanded the clinical applications of PEEK in implant dentistry. The material is currently utilized in several implant-related components, particularly in situations where esthetics, lightweight structures, and favorable soft tissue response are desired [6,22].

One of the most important applications of PEEK is the fabrication of customized implant abutments and healing abutments. The tooth-colored appearance of PEEK offers esthetic advantages over metallic components, particularly in patients with thin peri-implant mucosa or in highly visible regions. In addition, CAD/CAM technology enables the fabrication of highly customized components with excellent precision and reproducibility. Customized healing abutments play a key role in shaping peri-implant soft tissues and establishing an optimal emergence profile during the healing phase, while the favorable biological properties of PEEK may contribute to soft tissue health and stability around implants [14-16].

PEEK is also widely used in implant-supported provisional restorations. Its low density, adequate mechanical strength, and ease of milling allow the fabrication of lightweight provisional prostheses with satisfactory esthetic outcomes. Furthermore, the material can be easily modified and polished, making it suitable for temporary restorations during implant healing and soft tissue maturation [11].

Conclusion

PEEK has emerged as a promising material for implant dentistry, offering a combination of favorable mechanical, biological, and esthetic properties. Current evidence supports its use in several implant-related applications, particularly in transmucosal and prosthetic components. However, additional long-term clinical studies are required to fully establish its clinical performance and expand its indications.

Conflict of Interest

There's no conflict of interest.

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