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Peek: The Material of Choice in Prosthetic Dentistry: A Literature Review

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KEYWORDS

Polyether Ethyer Ketone, Adhesionbo nding, Acid Etching

ABSTRACT:

Introduction: PEEK and its various formulations represent a very interesting alternative material that can be used in prosthetic dentistry. The objective of this article is to synopsize the clinical use of Bio HPP (high performance polymer) for removable and fixed restorations.

Materials: - A search of 82 references on PEEK, especially Bio HPP, was performed.

Result- We have analysed very recent articles; Mechanical properties of PEEK (Bio Hpp) are closer to those of the dental tissues and this fact give an advantage of the material compared to the metal alloy and Zirconia.

Conclusion- This material is not only extremely interesting for the future, but possesses characteristics, suitable for clinical application today for Prosthetic works.

1. Introduction

Poly Aryl Ether Ketone (PAEK) is a semi-crystalline thermoplastic polymer; having melting temperature of 370^{O}C. PAEK comes from the family of Poly Ether Ether Ketone (PEEK) and Poly Ether Ketone Ketone (PEKK). Poly Ether Ether Ketone (PEEK)which is a white in colouris a radiolucent rigid material with thermal stability up to 335^{O}C. Bio HPP is ceramic reinforced semi-crystalline PEEK. The strength and abrasion properties of the material are improved due to it ceramic filler sit further allows the material to be veneered. Bio HPP, being a part of the PEEK family, it has been used in surgical procedure for years as it has excellent stability, optimal polishing properties and low plaque affinity. Not only this, it is highly suitable for precise fabrication of prosthetic restorations. The objective of this publication is to synopsize the application of PEEK and emphasize on use of Bio HPP in prosthetic dentistry.

2. Methods

A study was conducted on 82 articles which were selected, evaluated by their titles and abridgments. These was considered valid for relative and outright assessment of the Bio HPP compared to other prosthetic materials.

3.Discussion

Poly ether ether ketone (PEEK), a synthetic polymeric material used in medical orthopaedic for years[1, 2]. Peek comprises of an aromatic nucleus linked by ketone and ether group, providing it with a higher clinical stability[3,4].

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It has some advantages that promote PEEK as a good alternative of commonly used restorative materials. It is highly thermal resistant (melting point 343^{O}C) and does not degrade significantly, show low water solubility (0.5%), bio-corrosion in body fluids can be minimized, and the release of cytotoxic metal ions causing allergies and inflammation can be avoided[5]. As a result, PEEK extends the life of the prosthesis, protecting both the abutment and adjacent tissues[6]. In addition, PEEK is X-ray transparent and produces very few image artefacts, outperforming zirconia and metal alloys[7].

PEEK, being aromatic cannot be sterilized by gamma and electron radiation as it is resistant to both the rays[8]. Modulus of elasticity of PEEK, which is approximately (18GPa), nearly matches with cortical bone (15GPa.) making it a suitable material for dental implants. PEEK has the ability to be retooled easily by integrating other materials. For example, modulus of elasticity of PEEK can be increased 18GPa, at par with bone enamel and dentin by adding carbon fibre. Bone, dentin enamel and PEEK have similar tensile strength making the material appropriate for permanent prosthetic restoration[9]. There are some disadvantages of PEEK which can be managed by some treatment. Osteogenic properties of PEEK have limitations as compared to Titanium. PEEK's bioactivity can be improved by –synthetic osteogenic hydroxyapatite coating, increasing the surface roughness and addition of chemical[10]. Compared to traditional materials, the stiffness of PEEK is not enough to withstand loads[11]. Glass fibres or carbon fibres if added to PEEK enhance its mechanical strength[12,13]. PEEK is a greyish white colour material free of metal. In implantology PEEK show better esthetics than metal and its alloys. But it fails to achieve a satisfactory aesthetic outcome with zirconia a fixed dental prosthesis. Composite resin veneering is incorporated to improve this aesthetic effect of PEEK[14] but the inert surface of PEEK makes bonding between PEEK and composite veneer difficult[15]. PEEK's domineering mechanical properties may be counterpoise by aesthetic limitations. PEEK requires a composite veneer for improved aesthetics. However, inert surface of PEEK is difficult to bond, which remains a major obstacle to its possible widespread use in prosthetics. Several methods have been evaluated in order to enhance its adhesive properties– acid etching, plasma-treatment, air borne particle abrasion, laser treatment and adhesive systems. 98% sulphuric-acid etching can considerably improve the sear bond strength (SBS) of PEEK in association with better surface roughness value[16]. The process of acid etching induces the formation of porous and permeable surfaces in PEEK, enhancing its adhesion properties[17]. A single application of luting cement often does not provide a satisfactory SBS for PEEK, but combining luting cement with a suitable adhesion primer and surface modification agent method improves performance. The available research results are still incomplete and further research is needed to determine the optimal combination for PEEK adhesion. Bio HPP- It is Bioactive PEEK with ceramic filler. It is created and optimized for dental use. Bio HPP is a part of PEEK family and is applied in surgical procedures for years. For dental use, the PEEK is reinforced with ceramic micro particles for better polishing of the restorations. These ceramic fillers have a size of about 0.3-0.5microns and occupy20% of the total volume of Bio HPP[18]. Because of their micro size, homogeneity is achieved in the microstructure of the polymer. The high degree of polishability of the material results in a lack of plaque retention and colour stability over time. Bio HPP almost nears to bone as possible, due to its modulus of elasticity (approximately 4GPA), this is very important in implant treatments where torsional forces can occur. Bio-HPP's elastic module, which is close to cancellous bone, transmits chewing pressure as gently as possible, reducing the risk of fractures[19]. Bio HPP is particularly suitable for allergic patients with because the water solubility of the polymer is very low. The finished Bio-HPP restoration is very light in weight. Kistler et al, 2013[20] conducted a study demonstrating that it is very much resistant to abrasion. Because of its lighter weight and low corrosion, it can replace chromium-cobalt dental alloy for RPD framework[21]. Bio HPP can be fabricated using CAD/CAM and lost wax technology[22]. Schwitalla & Muller, 2013[23] showed PEEK as a potential substitute material for manufacturing dental implants. In the field of dental implantology, the mechanical properties and bio compatibility makes PEEK/Bio HPP a material of interest.

Application of Bio HPP in Prosthodontics-

The three main factors of fixed dental restoration:

a. Biomechanical behaviour (wear resistance and fracture resistance)

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b. Marginal fit and

c. Aesthetics

Metal has been almost replaced by Zirconia in fixed dental prosthesis for its excellent aesthetics[24]. Zirconia exhibits better wear resistance than metal alloys[25], superior mechanical properties makes PEEK an alternative material to zirconia. Compared to zirconia PEEK is significantly less abrassive[26].

A. **Crowns** –

Considerable wear resistance must be possessed by crown material. Abhay et al[27] reported that zirconia crowns demonstrate superior resistance to displacement in comparison to PEEK crowns, while also exhibiting a higher level of abrasiveness. Despite PEEK crowns being more susceptible to displacement than zirconia, it also has a much lower modulus of elasticity, which distributes stresses due to deformation more evenly. PEEK has flexural strength (140-170 MPa) compared to conventional materials, so more fracture resistant. Shetty et al found that crowns with PEEK copings showed higher strength than crowns with zirconia copings[28]. Precise marginal fit in cervical region for success of crowns which reduces adhesive dissolution, dentin hypersensitivity, secondary caries and periodontitis. PEEK coping had better marginal fit and internal adaptation than crowns with zirconia coping, and both were clinically acceptable[29].

B. **Fixed Partial Denture** –

For fixed partial dentures (FPD) fabrication, the primary factors to be taken into account are stress distribution, fracture resistance and fracture pattern[30]. The Young's modulus of PEEK (3-4 GPa) is lower when compared to that of Co-Cr alloy (220 GPa). Therefore, when an occlusal load is applied to the pontic, PEEK absorbs and protects the abutment from the load [31]. According to Rauch et al, when considering PEEK's clinical usefulness for FPDs, it has been observed that PEEK necessitates a shorter fabrication time and possesses a lighter weight compared to zirconia. However, zirconia showcases superior aesthetic outcomes in comparison to veneered PEEK, although both materials are deemed aesthetically acceptable[7].

C. **Post and Core** –

The post core material should have properties like high fracture and fatigue resistance, matching with root canal morphology and, Young's modulus matching with dentin (18.6 GPa)[32]. A post material with Young's modulus nearing to dentin typically produces a favourable stress distribution with higher stress at the post and lower stress at the fragile root and post-dentin interface. Cast alloy and zirconia posts have a higher modulus of elasticity a compared to dentin, creating intense stresses on the root that can lead to root fracture while the post remains intact[33]. Fibre reinforced composite (FRC) post distribute stress in a more balanced manner, lowering risk of root fracture but the posts are prone to fracture[34]. Recent results show as compared to metal alloy PEEK, as post and core material shows better aesthetic at-par FRC. PEEK's low elastic modulus is comparable to that of dentin.

D. **Removable Partial Denture Frameworks-**

Bio HPP can be used for partial denture frameworks but there is not sufficient information for the effectiveness of Bio HPP clasps for RPD. The addition of ceramic nanoparticles significantly increases the strength of the framework and this response to the need for a modulus of strength that is best suited for permanent restorations. Bio-HPP's application in prosthetic dentistry in the manufacture of removable dentures is as an obturator. High biocompatibility and low relative density (1.31 g/cm3) make this material of choice. There are other positive qualities – the crack resistance, the modulus of elasticity almost that of bone and the easy polishability and processing.

E. **Individual Implant Abutments-**

Bio HPP can be used as an substitute implant material because of its high biological tolerance. Bone resorption around PEEK and titanium superstructures is almost same. The micro-flora attachment to PEEK is similar to titanium and zirconia dioxide based ceramic abutments. The modulus of elasticity of PEEK nears to that of bone reducing stress and activates bone around the implant.

4. Conclusion: -

Because of the excellent mechanical, chemical, biocompatibility and aesthetic properties, PEEK can be considered as a good alternative to conventional

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materials for fixed dental prosthesis. PEEK prosthesis can perform better clinically than metal or zirconia. However, there are also some drawbacks when using PEEK for fixed prostheses. Because of its grey colour, it has inferior aesthetic effect to zirconia unless it is veneered with composite resin; however, the inert and hydrophobic surface of PEEK makes its bonding with composite resin and abutment teeth difficult. This is a barrier to wide spreaded option of PEEK over traditional prosthetic materials. To improve this quality, a variety of technique for surface modification and improvement of adhesive properties have been tried. Now-a-days investigations for new abilities to use PEEK in prosthodontics are conducted. These materials can be combined with metal alloys for alternative fixed restoration fabrication.

Scope of Further Improvement –

Fabrication technique is important for bonding behaviour and mechanical properties of PEEK, it still remains questionable which fabrication method is best for PEEK, whether 3D- printed, milled or heat processed. More effort should be given to identify the appropriate technique. Adhesive property of PEEK was proved unsatisfactory as neither alone application of luting cement, nor any significant or any preferred surface modification has determined its optimal bonding behaviour.[35]This denote that no extra effort should be made to determine the optimal amalgamation of luting cement and pre-treatment method to improve PEEK adhesion performance. This is another area that needs further advancement. The superior performance of PEEK in field of fixed restorations can be further improved by reinforcement of carbon or glass fibres, nano-sized silica or titanium dioxide particle filling or coating with titanium and methyl methacrylate. Some of these materials have also shown significant improved behaviour of the bonding strength of PEEK[36]. So, we can conclude by saying further research is required to study the fabrication technique, bonding properties and reinforcement of material which will make PEEK's prosthetic application easier.

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