Will Poly Ether Ether Ketone Outshine the Existing Dental Materials? - An Overview

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Abstract

PEEK stands for Poly Ether Ether Ketone.. It is a semi crystalline polycyclic aromatic linear polymer. It is a white and a radiolucent material that is rigid in nature. PEEK is the latest invention in the field of dentistry. It is known that this material can prove as a substitute for the existing dental materials. It is claimed that this has better properties than other materials. PEEK has been the center of attention for a lot of scientists looking for better alternatives to the existing materials. Various researches and reviews have been carried out in detail to study this material. The role of Poly Ether Ether Ketone in dentistry by itself has been a majorly studied topic. A literature review was carried out using a systematic search strategy and articles were found using keywords. Literature was taken from databases like PubMed and Google Scholar. Articles that discussed the properties of PEEK and its applications were included. Other articles which had data regarding the structure and its advantages were also included. This review summarized the properties of Poly Ether Ether Ketone. Its structure, and other applications in different dental materials were also discussed in detail.

Keywords: *Dentistry; Dental Materials; Implant Materials;Modifications of PEEK; PEEK;Properties*

Introduction

PEEK stands for Poly Ether Ether Ketone. It is a semi crystalline polycyclic aromatic linear polymer. It gained attention because of its great thermal stability. It is a white and a radiolucent material that is rigid in nature [1]. PEEK is the latest invention in the field of dentistry. It is known that this material can prove as a substitute for the existing dental materials. It is claimed that this has better properties than other materials [2]. It portrays many qualities that make it better than other materials. It is a strong material and has been proposed to be used in the framework for RPDs in dentistry [3]. RPDs and FPDs are the primary treatment choice for a partially edentulous patient. They should be able to provide comfort and aesthetic restoration to the patient [4]. The replacement of teeth by a denture can be called successful depending on a variety of factors [5].

Poly Ether Ether Ketone is being researched widely because it possesses many qualities that are not present in the existing conventional materials. It is known to be non-allergic and brings about lesser or no hypersensitivity or allergic reactions. It has a lower affinity to plaque; hence it will not facilitate lodging of infection causing bacteria and will protect the tooth from caries. To achieve higher aesthetic stability, polishing of a dental material is very essential. PEEK can be highly polished and hence will provide an aesthetic result. It has a good wear resistance. It will not wear out easily and add to the life of the dental appliance/material [6]. As discussed earlier, it has high temperature stability and is also more aesthetic [7]. This is important because when a patient is being given a denture, providing aesthetics and restoring normal function is very essential[8] [9]. Another advantage is that it has poor electrical and thermal

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conductivity and low frictional properties[10 11].

PEEK has been the center of attention for a lot of scientists looking for better alternatives to the existing materials. Various researches and reviews have been carried out in detail to study this material. The role of Poly Ether Ether Ketone in dentistry by itself has been a majorly studied topic. The applications of PEEK have been studied in the field of Implantology as well as Prosthodontics [12]. It has been researched to see if it can be used as a material for forming the framework of removable dental prostheses[13]. It has widely been studied to check if it can be the constituent of dental implants. Dental implants require stress bearing materials that do not give way easily and that also provide osseointegration without causing allergies. Various researches have been carried out to study PEEK as a dental implant material.

As every concept has certain downfalls, even PEEK possesses some disadvantages. Firstly, it is bio inert. It doesn't react much with the surrounding tissues, which makes it difficult to apply in the field of Implantology[14]. It may cause resorption of bone due to various causes. All of this will eventually lead to failure of the dental prostheses. It is hydrophobic in nature, and will not interact with bone; hence, more research is required to substitute it completely as an implant material [15]. It may also bring about allergic reactions in certain cases which cannot be predicted beforehand. It is not yet developed to its full potential and extensive research has to be carried out to understand its properties in detail.

This review on PEEK has been carried out because it has a tremendous potential that is yet to be discovered fully. It has excellent properties that are much better in various aspects when compared to the existing dental materials. It can be used in different areas like implants and RPD frameworks as well. It is a strong, durable and highly aesthetic material which can also be polished well. It can be introduced as an alternative to many existing materials. The aim of this research is to understand the emerging importance of PEEK as a material in dentistry.

What is PEEK?

PEEK stands for Poly Ether Ether Ketone. It is a polycyclic, aromatic, semi-crystalline structure that is best known for its array of properties. These properties are best suited for certain dental products hence PEEK has been introduced into the field of dentistry. It is basically a white/colourless thermoplastic polymer. It portrays high strength and good wear resistance amongst its various other plus points. It also has a high temperature resistance when compared to other dental materials. It has already been widely under use in the field of Implantology and prosthodontics [16].

Properties of PEEK:

PEEK has numerous properties that all contribute to its widely gained attention and property. It has a very low elasticity modulus, which is similar to bone[17]. It is known to be an insoluble material. The insoluble nature is attributed to its high temperature stability and low density. It is a white and rigid material that is also radiolucent. The radiolucency of this material proves very advantageous for its application in dentistry. PEEK has a low plaque affinity hence it would be helpful in preventing plaque induced dental diseases. Low plaque affinity ensures lesser periodontal and other dental problems. This is because Dental plaque is known to cause periodontal irritation.[18].Some studies showed that Aloe Vera also ensures lesser plaque affinity[19]. It has a great thermal stability thus, does not distort easily even under high temperatures. PEEK can be produced using CAD/CAM techniques which have gained importance due to the large number of benefits[20].

Exclusive features:

Due to the endless number of features that PEEK presents, it has gained popularity across various fields. The properties are being studied extensively to suit the particular requirements of the field. PEEK is a high performance polymer that is employed in medical as well as engineering fields. This wide range of application across various fields is due to its extremely favourable and distinct properties. It exhibits a good level of biocompatibility in most cases. As discussed earlier, it has excellent mechanical properties. It can be called an all in one material that can be employed in the dental field and yield better results[21 22]. PEEK is an inert material and does not exhibit any toxicity effects as far as facts are known. Because it will not cause any allergy/ toxicity, it can be substituted in patients that are allergic to titanium metal [23 24]. The modulus of elasticity of PEEK is in sync with that of bone, which adds on to the plus points[25]. Because of these numerous extravagant

properties, PEEK can be set to replace the conventional PMMA material in the upcoming years [26]. It is proven as the result of studies that PEEK does not cause cell damage in any way[27].

Applications of PEEK in Implantology:

PEEK is widely used as an implant material. When being employed as an implant material, it is necessary to maintain integrity of the implant. The stress to the bone has to be reduced[28]. While placing an implant, there are various factors to be taken into consideration. The fatigue caused due to masticatory forces should also be considered[29]. The material of the implant is extremely important [30]. It is said that PEEK can replace Titanium as an implant material in the future.

PEEK as temporary crowns:

PEEK is also used to make crowns that are produced through the process of Computer Aided Design and Computer Aided Milling. Ceramics are also used to replace missing teeth. But recently, PEEK proves to have more advantages over conventional materials [31]. Its advantage is that it is highly resistant to fracture. Such crowns are advantageous because they do not bring about attrition of the opposite tooth.

Role of PEEK in Orthodontics:

Another application of PEEK is the reinforcement of NiTi wires with this material. It may add to the flexibility of the material that is widely used in the field of Orthodontics. The most frequent application of PEEK is in the construction of Denture bases used in Dentistry. Prosthetic Rehabilitation is of utmost importance in patients that are missing teeth or have any bony defects[32].

PEEK in Maxillofacial Reconstruction:

PEEK can be directly bound to composites through polymerisation by light. This adds to the aesthetic component. Another interesting application of PEEK is seen in Maxillofacial Reconstruction. Conventionally, materials like PMMA, Copolymers, Silicone were used. Nowadays, even PEEK is being used to make prosthesis to reconstruct facial features [33 34].

Added Benefits:

As discussed in the above sections, PEEK can successfully replace titanium metal in the dental field. This can be done to provide optimum results to those that have allergic reactions to the titanium metal. It is a known fact that it has high strength, and it is also studied in vivo that PEEK has shown resistance to degradation. These properties compiled together would make the material- PEEK an ideal material for an implant[35]. PEEK should be used in making denture base materials whenever it can be used as it can preserve the supporting structures of the prosthesis[36]. It has lesser plaque affinity than conventional PMMA[37].

Modifications:

To overcome a few of the downfalls, PEEK has been modified by incorporating other materials like nanoparticles or reinforcement by fibre, carbon, etc. These modifications enhance the cell adhesion properties and thus, enhance the biocompatibility as well. When modified, it can also reduce peri-implant inflammation. To increase its elastic modulus and gain an altered resultant, PEEK has also been reinforced with Fibre, Carbon and Glass. The surface modifications lead to an alteration in the surface characteristics of the material. It improves the mechanical properties and hence improves biocompatibility as well[38]. This material was also modified and then used to make dental prostheses. These resultant prostheses made from modified PEEK, were lighter in weight, provided a better fitting and also was more functional [39]. Because PEEK is an inert material, various modifications have been tried and analyzed to make it more interactive and this also indirectly leads to a rise in tensile strength[40]. In recent times, microbes have started gaining resistance and easily bring about infection. Most infections are treated using oral antimicrobials. But to prevent this, incorporation of PEEK with Nanoparticles that have an anti-microbial activity may prove to be useful [4142]. Recently, more efforts are being taken to increase the bioactivity of PEEK as an implant. This is done by introducing bioactive materials [43].Lately a research was conducted to modify PEEK and use it as a substitute for fabrication of a resin bound fixed dental prostheses[44].

Carbon Fibre Reinforced and Glass Fibre Reinforced PEEK:

As discussed above, PEEK has been incorporated along with other materials to provide better properties.

Carbon-fiber reinforced PEEK showed greater compressive strength when compared to conventional. [45] Carbon-fiber reinforced PEEK has a modulus similar to that of bone and it can withstand fatigue strain [46] .In comparison to unfilled PEEK, glass fibre reinforced PEEK is proven to have increased mechanical strength and increased rigidity. [47] The tensile strength and flexural strength of GF/PEEK is higher than those of pure PEEK.[48]

BioHPP from PEEK family:

BioHPP is a High Performance Polymer belonging to the PEEK family. It is used in fabrication of prosthetic restorations. It is known to be the most stable non-metal material used in the field of dentistry [49] . It is a material with a wide range of advantages. It can resist fracture, it can be easily trimmed and is shock absorbing (ideal for implants). This material is non toxic and extremely biocompatible. As per clinical reports, it is suggested that BioHPP can be used to construct complete arch frameworks. [50] This material has been used as an alternative to make prosthetics over dental implants.[51] BioHPP has been in use in the field of medicine for more than 20 years due to its characteristic properties and low cost. [52]

Conclusion

This review was conducted to understand the basics of Poly Ether Ether Ketone (PEEK). It is a heavy polymer that belongs to the family of Poly Aryl Ether Ketone (PAEK). It is a semi crystalline polymer that is white and rigid in nature. It has great properties like strength, thermal stability and wear resistance amongst others. It is known that PEEK is used for dental procedures, implants and denture bases. A variety of properties were analysed in this review. There are multiple advantages as well as disadvantages for this material. The full potential of this material is not yet discovered. It may develop in the coming years and expand its range of applications.

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