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Review Article

PEKK (POLYETHERKETONEKETONE) AS A PROSTHETIC MATERIAL- A REVIEW

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ABSTRACT

Titanium, precious metal alloys and ceramics, such as zirconia, are commonly used in long-term dental applications. Each material has specific advantages. Recently, other materials have established themselves in the dental industry: fibre-reinforced thermoplastics, such as Polyaryletherketone (*PAEK*).PEKK is considered as the highest member of the Polyaryletherketone (PAEK) polymer family, this family of polymers is distinguished by its strong damping power and its highly biocompatible character, in addition, off-white color gives it a major aesthetic benefit too. It is having a density (less than 2g / cm3), resistance to pressure (between 200 and 300 MPa) and a modulus of elasticity which is comparable to that of dentin, enamel or bone. This relative flexibility and lightness are all particularly valuable from a clinical point of view for implant restorations. In this domain, we can say that PEKK can bring about revolutionary changes in restorative dentistry, in this review with limited available data on PEKK an attempt is made to evaluate the various mechanical properties of this material.

INTRODUCTION

Traditional materials used in dentistry, particularly metal alloys for crowns and bridges, are increasingly being swamped out of the market. These alloys serve as framework and are subsequently coated and aesthetically veneered with ceramics. Due to their mechanical characteristics, well-accepted mouth tolerance, vast clinical evidence and their simple processing, metal alloys have been the material of choice in dentistry for many decades. However when it comes to aesthetics metal alloy restorations have its own flaws, a major disadvantage of such restorations is increased light reflectivity, because of the opaque porcelain layered to mask the metal substrate Light reflecting from the opaque porcelain particularly at the cervical third of the restoration causes a light grey appearance to the adjacent gingival tissue.

The need for metal-free solutions in dental prosthetics already exists since quite some time and this trend gained even more importance through the recent introduction of zirconia, due to its very high stiffness, zirconium is applied in three to maximum four piece bridge frameworks. Hence, the patient receives an aesthetical, biological, high class dental prosthesis. The disadvantage of the material is the considerably higher price compared to bridge frameworks out of cobalt-chromium.

Through technological advancements in the field of high-performance polymers, these materials are now being used wherever the highest demands are made of materials: automotive industry, aerospace, semiconductor technology, outstanding properties also make high-performance polymers ideal for dentistry. Some products for temporary applications are being more and more established in the market: e.g.healing caps for dental implants or implant abutments.

For the state-of-the art manufacturing of crowns and bridges in milling machines, blocks out of high-performance polymers or PEEK are being offered, a new chapter is now being written with the introduction of materials that have excellent properties for a diversity of applications. Cendres+Métaux is exploring new paths with Pekkton®, a top product among thermoplastics.

PEEK, PEKK – these terms are both numerous and confusing, but these materials all have one thing in common: they belong to the family of poly aryl ether ketones, known as PAEK for short. PAEK are high-performance thermoplastics which, thanks to their chemical structure, have high strength, stiffness and good resistance to hydrolysis and are, thus, suitable for extremely demanding conditions.

When thermoplastics are processed, only the form and not their chemical structure is being changed, a crucial advantage when compared to thermoset polymers, the material also does not

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display any porosity or monomers. The material PEKK is the latest generation of the PAEK (poly aryl ether ketones) family; it stands at the apex of the quality pyramid of thermoplastics, unlike PEEK, PEKK displays both amorphous and crystalline material properties which makes PEKK particularly interesting it has unique mechanical, physical and chemical properties, PEKK lends itself to a broader range of uses than PEEK: up to 80% higher compressive strength than PEEK materials, wider processing window of parameters than PEEK. Mimicking nature is the future trend for dental products metals and ceramics, even if they are biocompatible, do not fulfill this claim, for instance, bone modulus matching may be important in applications where stress shielding should be minimized, By contrast, polymer-based products are increasingly acknowledged as better alternatives to stiff, rigid dentures in metal or ceramics solutions.

Hence the extensive profile of material properties of Pekkton® naturally makes it ideal for different applications in the dental field. The natural high strength and low modulus of Pekkton® products may be increased by the addition of fillers, stress-demanding applications are then made possible as the properties of human tissues are mimicked, stiffness, for instance, can be tailored to human hard tissues through the selection of fillers, their concentration and the processing technique of the resulting composite recipe.

Other important characteristics

- High flexural, fatigue, tensile strength,
- Ideal dimensional stability,
- Excellent wear and abrasion resistance,
- Compatibility with all current sterilization methods,
- Radiolucency.

According to the information from the manufacturer (Cendres+Métaux) and product distributor (anaxdent North America), the heat-pressed PEKK material used in this corresponds to European Union Medical Device Directive 93/42/EEC and carries the CE marking (European Union declaration of conformity) as a framework material for definitive prostheses. In the United States, the heat-pressed PEKK material currently carries the 510(k) clearance from the Food and Drug Administration as a framework material for long-term provisional prostheses, with no predefined expiration date. The 510(k) clearance for fabricating definitive prostheses is currently under final review by the Food and Drug Administration. Different medical device regulatory bodies may have various clearance statuses on restorative materials such as the PEKK.

DISCUSSION

In recent years, polyetheretherketone (PEEK) has become the choice of material when it comes to high performance polymers, however PEEK might not be the optimal choice for dental applications where aesthetic and long-term structural properties are of primary importance, because of its crystalline structure, PEEK's performance is limited, and the complex manufacturing process needs high accuracy.

Polyetherketoneketone (PEKK), has been specifically developed for dental applications, Pekkton can be adapted to the different structural and processing requirements needed by dental laboratories, unlike PEEK, the Pekkton line offers crystalline as well as amorphous structures, which means a wider range of products can be offered.

With the crystalline versions of Pekkton, products with improved mechanical properties, stiffness and chemical resistance can be obtained. Products made out of amorphous Pekkton, on the other hand, reach a higher flexibility and are easier to process. Due to the ideal viscosity of the material and its large working temperature range, geometrically-complex forms can be produced through casting and compressing the pieces under high temperatures, it has also a comparatively lower shrinking rates during the cool-down process, resulting in higher degrees of accuracy.

Crowns and bridges with a high chemical and mechanical resistance can be produced using crystalline Pekkton, however the most important mechanical properties can be reached through reinforcing Pekkton with a large amount of fibres. When producing polyetherketone parts in quantity they usually need to be machined, for serial production, injection moulding is the most economic alternative.

Depending on the required tolerances, crystalline materials may need to be reannealed to relax the internal tensions that accumulate during production. These post-treatments are usually time-consuming and costly. Pekkton, however, has a slow rate of crystallisation, making it possible to obtain tight tolerances without post-treatments. As it never has to be after-treated, Pekkton can be an interesting solution. With its greater processing flexibility, the Pekkton line will contribute to the development of successful products that provide both structural and aesthetic satisfaction[1,2,3,4].

Thus, with this backdrop, a study was done to evaluate the shear bonding strength of composite to PEKK by applying several methods of surface treatment associated with various bonding materials. PEKK specimens were assigned randomly to three different surface treatments (95% sulfuric acid etching, airborne abrasion with 50 µm alumina, and airborne abrasion with 110 µm silica-coating alumina) and five different bonding materials (Luxatemp Glaze & Bond, Visio.link, All-Bond Universal, Single Bond Universal, and Monobond Plus with Heliobond). Topography modifications after surface treatment were assessed with scanning electron microscopy. The results showed that regardless of bonding materials, mechanical surface treatment groups yielded significantly higher shear bonding strength values than chemicalsurface treatment groups. Unlike other adhesives, MDP and silane containing self-etching universal adhesive (Single Bond Universal) showed an effective shear bonding strength regardless of surface treatment method. It was conclude that mechanical surface treatment behaves better in terms of PEKK bonding. In addition, self-etching universal adhesive (Single Bond Universal) can be an alternative bonding material to PEKK irrespective of surface treatment method[2].

Yet another study was done to analyze the influence of titanium dioxide (TiO_2) specimens of two content and antagonistic material on the wear of polyetherketoneketones (PEKKs). PEKK materials containing either10 wt% or 20 wt% TiO_2 particles were dynamically loaded in a chewing simulator with 49 N and additional thermal cycling. Within the limitations of this in vitro study, the following conclusions were drawn:

depending on the antagonist roughness the amount of TiO2 particles had a significant influence on the wear behavior of PEKKs, against Zr or the same PEKK as the antagonist, the amount of wear was comparable to the amount of wear of dental enamel, Wear of the tested PEKKs against themselves showed the lowest rates in this study[1].

The prosthesis design with PEKK framework material may be contraindicated for patients with opposing fixed dental prostheses or natural dentition, a history of bruxism, or unfavorable implant distribution (the need for extended distal cantilever or pontic length on the framework design). Sufficient restorative space is also required for the fabrication of individually luted ceramic crowns. In the event of decreased restorative space, composite resin can be used to veneer the PEKK framework. The manual fabrication process can also increase the complexity of the laboratory procedures, which in turn will require the skills of more experienced dental technicians.

CONCLUSION

PEKK resins have an enormous advantage over PEEK materials in long-term dental applications when polyaryl matrices are exposed simultaneously to repeated stress and a wet environment. PEKK resins, in our view, will contribute to the development of successful products that will provide structural and aesthetic satisfaction.

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