Applications of BioHPP in Prosthetic Dentistry

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BioHPP is not only extremely interesting for the future, but possesses characteristics suitable for clinical application today, for endocrowns, small adhesive bridges, temporary prostheses and for immediate loads on implant restorations. The excellent aesthetics and the possibility of simple reprocessing of the restorations made with this material invite its clinical application.

BioHPP crystalline poly ether ether ketone PEEK ceramic fillers dental prostheses elasticity rigidity immediate loading

1. Introduction

Innovations in the field of implant prosthetics on materials that can be used both in temporary rehabilitation, such as in immediate loading and definitive restorations, have merged with modern digital techniques, making the use of resins and non-metallic materials increasingly interesting. Although metal prosthetic restorations still represent an extremely recommended solution today for the marginal precision, duration over time, excellent bond of the current alloys with the ceramic coatings, and for the possibility of laser sintering, milling the structure, or to use a casting technique, PEEK and its various formulations represent a very interesting alternative, thoroughly investigated in recent literature.

Metals prosthetic rehabilitation have a very different modulus of elasticity from those of bone; these rigid materials discharge important occlusal forces on the prosthetic system, without any cushioning, and therefore, for the application in immediate loading techniques, the need arises to use different materials, equipped with the ability to reduce the load on implants [1]. Since the modulus of elasticity for PEEK at around 12 GPa is similar to that of cortical bone at around 15 GPa, it is particularly suitable for dental implants.

Since the matherial is extremely inert and develops a dense structure as a result of the processing during the compression-molding process, there is good biocompatibility, as has already been proven during the manufacture of plastic abutments [1][2].

Polyetheretherketone (PEEK) has been used in medicine for years, particularly in Orthopedics for more than 40 years [2]. This product, and its novel high-performance evolutions, attracted the attention of researchers for the notable mechanical properties. Over the years, this material has evolved, leading to its reinforcement by inserting fibers or ceramics inside (less than 0.5 µm in diameter) to improve its mechanical capabilities, resistance to stress, and aesthetics [3].

BioHPP® (Bredent, UK) is a partially crystalline poly ether ether ketone (PEEK) that is strengthened using ceramic. The ceramic fillers improve the strength, abrasion properties, and allow it to be veneered. As a result, BioHPP® is the only material to achieve the perfect balance between elasticity and rigidity, with important aesthetic characteristics on its side, thanks to the possibility of being veneered [4].

A BioHPP® prosthesis considerably reduces the maximum values of masticatory forces, both vertically and lateral, compared to titanium, zirconium, or ceramic distributed on the prosthetic structure and in the bone [4][5]. One of the functions of Sharpey fibers is to cushion the distribution of occlusal forces at the bone level. This capacity is often lower on devitalized teeth and completely missing in the case of bone ankylosis/osseointegration at the implant level. From a mechanical point of view, this has unfavorable effects on osseointegration, and from a physiological point of view there are effects on the antagonistic teeth as wear. The interposition of a material such as BioHPP®, often used as an abutment between the bone/implant interface and the prosthesis, guarantees greater safety in immediate loading techniques, thanks to its mechanical characteristics [1][5].

The use of this material is indicated in fixed prostheses for single crowns, bridges with up to two pontics, bonded bridges (Maryland bridges), and in removable prostheses for superstructures with or without friction elements, secondary parts in the presence of bars, individual abutments, Toronto Bridge, or, directly, crowns [6]. Particularly with fixed prostheses in a jaw already restored with metal restorations, the low BioHPP® modulus of elasticity can therefore help achieve normal chewing sensation and reduce the amount of force transmitted with implant-based restorations in the manner of “progressive bone loading”, reducing also the risk of antagonist chipping due to excessive occlusal load during occlusion [4][5]. The possibility that this material has to adapt perfectly to the partially or completely digital workflow and radiation-free diagnostic examination allows for obtaining high levels of aesthetics, and for being able to propose a precise treatment plan for the patient [7][8][9][10][11]. The main solution for its clinical application to date is still represented by cementation, unless intermediate metal components are used that allow it to be screwed, avoiding the various problems of cementation, which, however, can follow traditional techniques without particular differences using adhesive cements, composites, zinc oxide without eugenol, and zinc oxide with eugenol, avoiding only glass ionomer and zinc phosphates cements [12][13].

What makes this material extremely interesting is that it achieves a perfect balance between elasticity (about 4.200–4.800 MPa) and stiffness (flexural strength 180–185 MPa), weight and breaking strength (from 700 N to 1600 N), physiologic integration, and resistance to plaque (bacterial adhesion comparable to that of zirconium oxide or veneering composites, with perfectly polished surface, polishing up to <0.02 µm) [4][6].

Considering the characteristics of this material, it adapts perfectly to the prosthesis on implants, but less so to the one on the tooth. It must be considered that the dental implants alone represent the answer to the medical needs of more than 800,000 individuals in the United States (US), and more than 1.8 million in the European Union (EU). Often, the placement of a limited number of strategic implants makes it possible to propose low-cost implant therapies, which are suitable for a large part of the population, and these materials, resistant, economical, and suitable for immediate loading represent the future of this kind of rehabilitation [5][6].

2. Current Insights

Peri-implant health is extremely delicate, and strongly correlated with the type of prosthesis, the hygiene of the product and the control of the load distributed at the bone level [10][14]. It is now evident in the literature that the levels of inflammation of the peri implant sulcus, also as a function of the different biological width and therefore of the different implant type, must be maintained and controlled, and to favor this it is necessary that the implant supported prosthesis guarantees excellent marginal closures, cleanable profiles, and does not favor the accumulation of plaque [15][16][17]. The shock absorbance as a feature of this implant material is extremely relevant, and allows for performing an implant rehabilitation, even complete, with interesting mechanical and biological characteristics: It is known that overload cannot directly cause peri-implantitis, but participates as a factor, together with the levels of inflammation that it maintains higher as a stimulus for bone resorption, in the development of implant pathology [18].

CAD/CAM BioHPP® frameworks exhibited not only shock absorbing, but also good marginal fit and fracture resistance and good retention force [4][19].

BioHPP® demonstrates a high biocompatibility, even superior to Zirconia in certain characteristics, and can be superimposed on the materials commonly used for implant restorations [6][20].

Use of different conditioning protocols had a significant effect on the final bond strength of composite resin cement to PEEK surface, but always at an excellent level, guaranteeing a perfect combination between the two materials [12].

Regarding the mechanical characteristics and physical properties of BioHPP®, promising fracture strengths and fracture types were found for the ceramic reinforced PEEK abutments with titanium base [21]. Ardakani et al. researched differently than other authors, but about a different and more complex application of BioHPP®; the state “BioHPP is not a suitable substitute for metal reinforce to enhance the Fracture Strength of PMMA denture base material” [19]. Also, wear behavior of the BioHPP® is extremely suitable for clinical use in dentistry [22]. The main PEEK characteristics are due to its low elastic modulus, similar to that of bone, its low hardness, which will not cause an abrasion of the opposing tooth, which does occur in the case of ceramic [23]. Rasheed et al. state that the shear bond strength of PEEK is similar to that of zirconia, showing the advantage that with the right surface treatments it is also the best adhesive solution [12][24]. Furthermore, the PEEK crowns showed minimal abrasion, better stress modulation through plastic deformation, and good color stability, which makes it a promising alternative to zirconia for fabrication of the crown [25][26][27][28]. PEEK has a low specific weight that permits the fabrication of lighter prostheses, providing high patient satisfaction and comfort during function [29]. For this reason, BioHPP could be used as a promising alternative denture base material with good adaptation, retention, and mechanical properties [30].

The study of Lalama et al. showed that heat-pressed PEEK post and core restorations resulted in higher accuracy when compared to the CAD/CAM method [23]. BioHPP PEEK can be fabricated via CAD/CAM technology by milling

PEEK blanks. It can also be pressed by using granular or pellet-shaped PEEK [31][32][15][16][17].

Furthermore, for the application of this material in the production of endocrowns, the evidence is numerous and in agreement. Poly infiltrated ceramics should be considered as a proper material to be used as an endocrown material; furthermore, they allow for easy reprocessing in case of failure [33]. Lithium disilicate showed a better marginal and internal fit compared to PEEK. However, the reinforced PEEK marginal fit is also within the clinical acceptable range [34]. The results are also clinically acceptable in comparison with Zirconia inlay restorations [35]. BioHPP provides very good clinical results due to the structure, but also the polymerization method, namely heat pressing. It has no abrasive effect on the remaining teeth, has white color suitable for fully anatomical use, and insures no ion exchange in the mouth, no discoloration, excellent stability, and optimal polishable properties [36]. However, lithium disilicate remains the gold standard of this type of rehabilitation [37]. Therefore, also for this application, BioHPP® has proven to have excellent characteristics and clinical reliability.

Regarding the retention and wear characteristics of this material, the results are excellent, guaranteeing long-term good results both in terms of resistance and wear [37][38].

PEEK may be a suitable material for removable prosthesis and a telescopic crown technique when used on zirconia crowns [38]. For its future applications, it turns out to be an excellent material also to replace the Cr-Co bars, and considering its positive bond with the composite materials previously highlighted, it turns out to be of a high level [39][40][41].

Regarding Zoidis et al. and Andrikopoulou et al., who expressed less positive comments than other authors, it is also necessary to underline that these are two of the first works published on this topic (5 years ago), and are among the oldest included in the study. This latter fact may be an indication of how the consideration of these materials has changed in just 5 years [3][42].

Furthermore, excellent stability and optimal polishable properties allow the material to have a low affinity for plaque, which hardly aggregates as a biofilm on its mirror-polished surface [36][15][16][17][43].

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