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RESEARCH ARTICLE

PEEK – A VIABLE ALTERNATIVE TO TITANIUM

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ABSTRACT

Titanium and titanium alloys are widely used for fabrication of dental implants and have been the gold standards in tooth replacement. Many potential immunologic and esthetic hazards compromise the success rate of titanium implants. Therefore, there has been a necessity for the introduction of novel technologies that suffice the properties of the titanium implants biologically and esthetically. Poly-ether-ether-ketone (PEEK) implants were introduced into dental implantology as a viable alternative to titanium implants. They seem to be a suitable implant material because of their tooth like color, mechanical properties, biocompatibility, and ease in the solderability of PEEK implants. Although they possess sufficient merits, longitudinal studies with large sample sizes and systematic evaluation will provide a more comprehensive view of PEEK dental implants.

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INTRODUCTION

The rehabilitation of completely and partially edentulous patients with dental implants is a scientifically accepted and well documented treatment modality. The material of choice for oral endosseous implants has been and still is commercially pure titanium (Williams *et al.*, 1987). Currently, titanium and titanium alloys have become a gold standard for tooth replacement in dental implantology. These materials have attained importance because of their excellent biocompatibility, favourable mechanical properties, and well documented beneficial results (Kurtz and Devine, 2007). Despite the efficacy of this material, few disadvantages have lead to search for new materials which can replace titanium and its alloys in medical field as well as implant dentistry. The principal disadvantage of titanium is its dark greyish colour, which often is visible through the peri-implant mucosa, therefore impairing esthetic outcomes in the presence of a thin mucosal biotype (Skinner, 1988). Unfavourable soft tissue conditions or recession of the gingival may lead to compromised esthetics. This is of great concern when the maxillary incisors are involve (Koca *et al.*, 2010). Furthermore, it has been suggested by various investigators that metals are able to induce a nonspecific immunomodulation and autoimmunity. Galvanic side effects after contact with saliva and fluoride are also described (Sarot *et al.*, 2010). Although allergic reactions to titanium are very rare, cellular sensitization has been demonstrated (Anneaux *et al.*, ?). To overcome these limitations and minimize negative biological reactions, researches have been focused on designing alternative substitutes to titanium. Poly-ether-ether ketone (PEEK) is one of the promising novel materials.

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Poly-ether-ether-ketone (PEEK)

When two or more substances such as polymer, fibers, or powder are combined at a microscopic level, the resulting material may demonstrate macroscopic physical properties that are superior to those of either of the constituent parts. Such combinations are termed as composite materials. The term composite is usually used when the reinforcing component comprises long, continuous fibers (Vaughan and Stevens, 2001). Poly-ether-ether-ketone (PEEK) polymer has been of interest to the medical implant community since the late 1980s, substantially because of the material's versatility, compatibility with modern imaging technologies, excellent mechanical properties and biocompatibility (Vaughan and Stevens, 1995). PEEK is a relatively new family of high temperature thermoplastic polymers, consisting of an aromatic backbone molecular chain, interconnected by ketone and ether functional groups. The chemical structure of polyaromatic ketones confers stability at high temperatures (exceeding 300°C), resistance to chemical and radiation damage, compatibility with many reinforcing agents (such as glass and carbon fibers)and greater strength (on a per mass basis) than many metals (Vaughan and Stevens, 1995). Historically, the availability of polyaromatic polymers arrived at a time when there was growing interest in the development of "isoelastic" hip stems and fracture fixation plates with stiffness comparable to bone (Kumar and Adams, 1990). By the late 1990s, PEEK had emerged as the leading high performance thermoplastic candidate for replacing metal implant components, especially in orthopedics and trauma (Stober *et al*., 1984). In 1992, PEEK was used for dental applications, first in the form of esthetic abutments and later as implants. Since then many variations in the composition have been carried out to modify and improve upon the characteristics of the implant (Searle and Pfeiffer, 1985). The reinforcing agents used may be carbon fibers, beta-tricalcium phosphate, hydroxyapatite or titanium dioxide contained within a PEEK matrix (Karger-Kocsis and Friedrich, 1986). The filler content makes the implant isoelastic, i.e. density and elasticity (Young's modulus) identical to bone. Although pure polyaromatic polymers exhibit elastic modulus that varies from 3 to 4 GPa, this value can be modified to achieve a modulus close to cortical bone (18 GPa) with the addition of fibers (Lin *et al*., 1996).

On the other hand the Young's modulus of titanium and its alloys vary from 110 to 150 GPa (Hamdan and Swallowe, 1996). It has been proven that a big difference between the elasticity of the implant material and bone leads to greater stress generation due to differential deformation under load (Cady *et al*., 2003). This stiffness mismatch can lead to bone resorption as a result of stress shielding. The isoelasticity of PEEK composites ensures that they warp identically to bone and thus produce a more homogenous distribution of stress along the implant bone interface (Rae *et al*., 2007). In addition to matching the stiffness of bone, PEEK with reinforcing continuous fibers has excellent strength, fatigue resistance, and durability. Also research has shown that this material is resistant to the effects of steam, gamma irradiation, and boiling saline solution with no significant effect on transverse flexural strength (Brillhart and Botsis, 1992). Additionally, PEEK polymer carbon composites have excellent compression strength durability following conditioning in the physiological saline. It has been shown to be strong and durable composite material in extremely aggressive environment of the human body (Brillhart and Botsis, 1991).

Various medical imaging methods, such as computer tomography (CT) and magnetic resonance imaging (MRI) are not metal friendly; the presence of metallic implants i.e. titanium and its alloys significantly and negatively impacts the quality of the resulting images. On the other hand the implants made of reinforced PEEK polymer are radiolucent and this feature allows avoiding scatter in further CTs or MRIs, something that has proved to be a great boon for this material in its neurosurgical and orthopedic applications (Brillhart and Botsis, 1991). Their white colour makes them ideal for use in the esthetic zone. Another matter of great convenience is the fact that polymer-composites do not generate heat when they come in contact with a high speed rotary cutting bur (Nisitani *et al*., 1992). As a result, the coronal portion of the single piece implant can be immediately modified (like crown preparation for FPD) to meet the prosthetic requirement (Tang *et al*., 2004). Polyetheretherketone has shown promise in its many forms in medical application. It has osteointegration potential through osteoconduction that has been confirmed by clinical results (Akay and Aslan, 1995). Wenz *et al*. (1990) reported that modulus effects and surface phosphonylationsupport osseointegration and bone formation on PEEK polymer surfaces. They concluded that the carbon fiberreforced-poly ether ether ketone (CFRPEEK) polymer, having surface immobilized calcium ions, should be viewed as a clinically preferred alternative to titanium alloys. Histopathlogically and histomorphically no discernible difference was observed between titanium alloy and CFR-PEEK polymer endosseous dental implants.

Conclusion

PEEK implants possess sufficient merits to warrant further clinical investigation. A few short-term clinical reports are available and provide satisfactory results, controlled clinical trials with a follow-up of 5 years or longer should be performed to properly evaluate the clinical performance of PEEK implants and to recommend them for routine clinical use. Their use in the esthetic zone can be of significant advantage to the surgeon as well as patient. Longitudinal studies with large sample sizes and systematic evaluation will provide a more comprehensive view of PEEK dental implants.

REFERENCES

Akay, M. and Aslan, N. 1995. An estimation of fatigue life for a carbon fibre poly ether ether ketone hip joint prosthesis. *Proc. Inst. Mech. Eng*., [H]; 209(2):93–103.

Anneaux, BL., Taylor, MS., Shih, M. and Shalaby, SW. Biomechanical properties of osseointegrated PEEK based and metallic endosteal dental implants. Society for Biomaterials.

Brillhart, M. and Botsis, J. 1991. Fatigue fracture behavior of PEEK, 1: effects of load level. Polymer; 32:1605- 11.

Brillhart, M. and Botsis, J. 1992. Fatigue fracture behavior of PEEK, 2: effects of thickness and temperature. Polymer; 33:5225–32.

Cady, CM., Blumenthal, WR., Gray, III GT. and Idar, DJ. 2003. Determining the constitutive response of polymeric materials as a function of temperature and strain rate. *J. Phys. IV France*., 110:27–32.

Hamdan, S. and Swallowe, GM. 1996. Strain-rate and temperature dependence of the mechanical properties of polyetherketone and polyetheretherketone. *J. Mater. Sci*., 31:1415–23.

Karger-Kocsis, J. and Friedrich, K. 1986. Temperature and strain-rate effects on the fracture toughness of polyetheretherketone and its short glass-fibre reinforced composite. *Polymer,* 27: 1753–60.

Koca, O.L., Eskitascioglu, G., Usumez, A. 2005. Three-dimensional finite element analysis of functional stresses in different bone locations produced by implants placed in the maxillary posterior region of the sinus floor. *J. Prosthet. Dent*., 93:38-44.

Kumar, S. and Adams, WW. 1990. Electron beam damage in high temperature polymers. *Polymer,* 31(1):15–9.

Kurtz, S.and Devine, J. 2007. PEEK biomaterials in trauma, orthopedic, and spinal implants: *A Review. Biomaterials*; 28:4845-69.

Lin, SH., Ma, CCM. and Tai, NH. 1996. Mechanical properties and morphology of different carbon fiber lengths in reinforced polyetheretherketone (PEEK) composites. *J. Adv. Mater*., 28(2):56–62.

Nisitani, H., Noguchi, H. and Kim, YH. 1992. Evaluation of fatigue strength of plain and notched specimens of short carbon-fiber reinforced polyetheretherketone in comparison with polyetheretherketone. *Eng. Fract. Mech*., 43(5):685–705.

Rae, PJ., Brown, EN. and Orler, EB. 2007. The mechanical properties of poly (ether-ether-ketone) (PEEK) with emphasis on the large compressive strain response. *Polymer,* 48:598–615.

Sarot, Contar, da Cruz, Magini, 2010. Evaluation of the stress distribution in CFR-PEEK dental implants by the three-dimensional finite element method. *J. Mater. Sci. Mater. Med*., 21:2079-85.

Searle, OB. and Pfeiffer, RH. 1985. Victrexpoly (ethersulfone) (PES) and Victrex poly (etheretherketone) (PEEK). *Polym. Eng. Sci*., 25(8): 474–6.

Skinner, HB. 1988. Composite technology for total hip arthroplasty. *Clin. Orthop. Relat. Res. Oct*., (235):224 36.

Stober, EJ., Seferis, JC. and Keenan, JD. 1984. Characterization and exposure of polyetheretherketone (PEEK) to fluid environments. *Polymer,* 25:1845–52.

Tang, SM., Cheang, P., AbuBakar, MS., Khor, KA. and Liao, K. 2004. Tension–tension fatigue behavior of hydroxyapatite reinforced polyetheretherketone composites. *Int. J. Fatigue*, 26:49–57.

Vaughan, AS. and Stevens, GC. 1995. On crystallization, morphology and radiation effects in poly (ether ether ketone). *Polymer,* 36(8): 1531–40.

Vaughan, AS. and Stevens, GC. 1995. On radiation effects in poly (ethylene terephthalate): a comparison with poly (ether ether ketone). *Polymer,* 36(8):1541–7.

Vaughan, AS. and Stevens, GC. 2001. Irradiation and the glass transition in PEEK. Polymer.; 42(21): 8891–5.[75]

Wenz, LM., Merritt, K., Brown, SA., Moet, A. and Steffee, AD. 1990. In vitro biocompatibility of polyetheretherketone and polysulfone composites. *J. Biomed. Mater. Res*., 24(2):207–15.

Williams, DF., McNamara, A. and Turner, RM. 1987. Potential of PEEK and CFRPEEK in medical applications. *J. Mater Sci. Lett*., 6(2):188-90. 19.

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