Esthetic Clasp Material: A Review.

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Abstract

The most economical and conservative treatment of partially edentulous condition is removable partial denture (RPD). Esthetics plays a salient function in determining the outcome of the prosthesis. The objective of accomplishing acceptable esthetics and preserving the inherent quality of a denture i.e., retention, stability, support and protecting the remaining teeth and underline tissue, is a challenging task. Display of the traditional clasp assemblies and framework made of different metals and alloys like base metal cobalt chromium alloy (Co–Cr), noble metal gold and its alloy, stainless steel, and titanium disrupts the esthetics, because its exhibition antagonizes with patient's confidentiality about prosthesis. This review article describes the two non-metallic materials Acetal resin and PEEK as alternatives clasp materials.

Keywords: Esthetics, Removable Partial Denture, Acetal Resin, Polyetheretherketone, Esthetic Clasp

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Introduction

Tooth loss is very unfortunate to any patient, and it is unavoidable due to various reasons. Partial or complete edentulism not only hampers one's functional need but also affects esthetics. Recently demands of implants supported prosthesis are increasing among patients in partially edentulous condition, but the various limiting factors considering anatomic, physiological, psychological, medical, and financial constraints are the reasons for changing the treatment planning to removable prosthesis. Removable cast partial dentures (RPDs) are the economical and suitable treatment choice for partially edentulous condition where minimal tooth modification is done, preserving the integrity of edentulous area and teeth.[1]

Fabricating an esthetic RPD while keeping away the show of metallic traditional clasp assemblies frequently creates an obstacle to the doctor as the demand for esthetic restoration is increasing day by day in contemporary society. Different methods have been implemented like use of intracoronal semi precision and precision attachment, lingually positioned clasps, engagement of undercut towards the tooth side and use of gingival approaching clasps. Metallic color and allergic response to some patient is not avoidable when conventional Cobalt- chromium (Co-Cr) alloys are used. To combat these shortcomings, non-metallic materials like polyamide, acrylic, polyester, polycarbonate, and polypropylene, which are mainly thermoplastic resin [2] are introduced. Among these materials acetal resin and poly ether ether ketone (PEEK) material are well accepted to be used for RPD framework.

The aim of this review article is to consider the non-metallic materials-acetal resin and PEEK for esthetic clasp fabrication.

History of Material

Acetal Resin

Polymer science research work has invented a new material, "Acetal resin" or "Polyoxymethylene (POM)", which is created by polymerization of formaldehyde. Acetal resin is a monomer free homopolymer, thermoplastic in nature and has a crystalline structure made up of methyl groups arranged alternating and linked by an oxygen molecule.[3] It is shown to have good biocompatibility and is used as artificial valve occluders and artificial hip.[3] In dental implant system (IMZ) [4] it has been used to make a component that absorbs stress.

Smith considered the possibility of using acetal resins as denture base.[5]. By examining the flexural properties, Turner determined the appropriate acetal clasp design and concluded that it should be shorter in length (mean 5 mm), and should have a relatively larger area in cross-section (mean 1.4 mm).[6] In 1971 it was proposed as a shatterproof thermoplastic resin framework material fabricated by Rapid Injection Molding System. In 1986, depending mainly on superior aesthetics, "Dental D" (QuattroTi Divisione Technopolimeri Biomedicali, Misano A, Italy), marketed this material. The clasps were flexible in nature and adjustment was not needed periodically to keep them tight. In early 1990s, Pressing Dental marketed the acetal resin (US by DENTSPLY Austenal), to be utilized for a complete partial denture framework along with tooth-colored clasps. [7]

"ClaspEze"- preformed tooth colored clasp was formulated by The Flexite Company in 1992. It is composed of nylon and is available in pink as well as in clear color shades. DENTSPLY in a few years instituted the 'Success FRS' (flexible resin system) for fabrication of Success denture by pressing method. Aesthetic Perfection T (patent pending), introduced by Cosmetic dental materials which is an advanced generation of acetal, polycarbonate and acrylic substances that can be fabricated by pressing. These materials provide superb esthetics with favourable mechanical properties and uncomplicated characteristics for processing. [7,8] Twenty various colour shaded acetal resin is available, among them seventeen are equivalent with "Vita" colour shade guide (Vitapan; VITA Zahnfabrik, Bad Sackingen, Germany) and rest are comparable with pink (Figure 1 and 2).[9]

Poly ether ether ketone (PEEK)

PEEK comes under the polymer family of PAEK (poly-aryl-ether-ketone). It has a molecular core structure of aromatic compounds with combinations of other functional groups which have the aryl rings like ketone (–CO–) and ether (–O–). [10]

In 1978, a bunch of English scientists produced Poly-ether-ether-ketone (-C6H4-OC6H4-O-C6H4-CO-) n, structure of which is semi-crystalline, polycyclic aromatic compound arranged in a linear pattern and thermoplastic polymer material. [11] In the starting of 1980, Victrex PLC then ICI (imperial chemical industries), presented PEEK to be used first in engineering application. Initially it was used for manufacturing of industrial appliances in aircraft, turbine blades, bearings, piston parts, cable insulation and compressor plate valves. Invibio Ltd company (Thornton-Cleveleys, UK) proposed the material to be incorporated for biomedical purpose in 1998. Victrex PEEK business company (Imperial Chemical Industry, London UK) launched PEEK-OPTIMA for persistent injectable uses in same year. [12]

By the late 1990s, PEEK started to replace metal components of implant fixture as a

high-performance thermoplastic material, in the surgery of traumatic injury of vertebra. When the fiber of carbon is incorporated into PEEK (CF/PEEK), it revolutionized as material for fixation of fractured bones and artificial femoral prosthesis. [13] Since 1996, PEEK has been used for spinal implants After those, studies are still ongoing to use PEEK as an alternative to dental implant. Panagiotis Zoidis in his experiment used modified PEEK material (Bio-HPP) in distally extended (Kennedy Class 1 and Class 2) case as denture framework and at one year follow up it was noticed that there was no breakage of clasp. He also found that clasp retention was satisfactory and color stability was present. [14]

Properties

Properties of Acetal Resin and PEEK are discussed in Table 1.

Experimental results

- **Acetal Resin**

According to Fitton that for retention, resilient clasps made of resin engages undercut areas. Due to the low elastic modulus, the clasps made of resin, needed to have an increased cross-sectional dimension than the metal clasps" [3]

Turner et al. concluded that having similar stiffness of a 15 mm * 1-mm dimension Co–Cr clasp, the resin clasp should have length 5mm shorter but with a 1.4 mm diameter of cross-section. [16]

An experiment of Martinez-Gonzalez et al showed that post-core of acetal resin treatment in maxillary canine (extracted) when loaded at 45° angulation with a forward speed of 0.5mm/minute, resisted the fracture that was comparable to conventional post and core made of metal. [17] Being a radiolucent material, it can be easily used as positioning stent in maxillectomy patient where post operative radiotherapy is planned.[18]

Arda and Arikan mimicked thirty-six months intra-oral application of acetal resin clasps and estimated the retentive capability and deformation, comparing with Co–Cr clasps. It was revealed that the acetal resin clasps were not deformed, whereas the Co–Cr clasp showed increased distance between the retentive and reciprocal tips.[19]

Studies regarding the solubility and absorption of water, between white and pink acetal resins, the acetal resin of pink shade, revealed significantly less water absorption than the conventional clasps made of acrylic and white acetal. The solubility and absorption of water of acetal resin were well under the ISO limitation.[20]

- **PEEK**

Lieberman et al.'s [26] in vitro research comparing the water absorption and solubility PEEK, PMMA and composite resin revealed that the clasps made of PEEK has the lowest values.

According to Beuer et al., PEEK has higher resistance to fracture than ceramics and zirconia, and PEEK can be effortlessly reinforced by other materials. [27]

- **Modification of PEEK**

The Young's modulus of unmodified PEEK is on lower side. So retentive property of clasps made from this material will be low compared to metallic clasps. Various reinforcement of PEEK has been created like fibers of carbon incorporated PEEK (CFR-PEEK) and glass fiber-incorporated PEEK (GFR-PEEK), as well as 20% ceramic reinforced (BioHPP PEEK) PEEK.

Elastic modulus of CFR-PEEK and GFR-PEEK is 14 GPa and 12 GPa respectively.[10]

Tannous et al.'s [28] in vitro study revealed that the PEEK clasps have lower resistance than the cobalt – chrome clasps. The fatigue strength for BioHPP (Bredent GmbH Senden, Germany) is very high (1200N). BioHPP can be used in RPD framework fabrication due to its excellent polish and natural aesthetic, possibility of corrections, and excellent stability. [29]

Costa-Palau S et al., fabricated maxillary obturator prosthesis using PEEK and found that the PEEK simplified the process of forming of the area of antrum of obturator and evolved in significant decrease in weight of the obturator prosthesis. Retentive features, aesthetics as well as comfort of patient were greatly improved. Constructing obturator with PEEK-OPTIMA is better substitute to traditional substances and fabrication process for the patients with large oral-nasal defects. [30]

Unmodified PEEK shows hydrophobicity with a WCA (water contact angle) of 80–90 degree and is also bioinert. Thus, the PEEK needs to be modified by the addition of fillers to decrease the contact angle. [31

Aesthetic clasp fabrication

Lab Technique for Acetal Clasp [32,33]

- It involves a special type of equipment for processing. It will constantly check the melting point, number of softening times, proper injection molding and the ensuring pressure cooling.

- First, the duplicated cast along with the wax framework is placed 2.5 cm away from the one end of the special flask (Muffle Type 100; Pressing Dental Srl) to be used for injection molding.
- After closing of the flask Type IV gypsum material is put into the flask through the hole of one end. The melted flask is then removed.
- Then the selected coloured acetal resin cylinder is placed into the passages of the injection machine of J-100 (Pressing Dental San Marino, Italy) with a special tweezer.
  Then the flask is kept into the machine which is planned accordingly; melting point: 220°C, 20 minutes of pre-injection time: at the fixed temperature, 3 minutes at the maintained temperature of post-injection time: injection pressure: 4 Bar.
- Lastly the clasp assembly is deflasked.
- Then the rough areas of the clasps are smoothened by grit size of 600, silicon carbide papers (Struers Scientific, Denmark). Next, polishing is carried out by rubber points first (Pressing Dental Srl), and then by polishing paste (Universal Polish; Pressing Dental Srl)

PEEK Clasp

PEEK components are prepared by extrusion, injection and compression molding techniques. [34] Highly precise prostheses without compromising quality of material can be fabricated in a short time by Rapid Prototyping and CAD CAM milling from PEEK disc (PEEK Juvora™ discs by Invibio® and Juvora™ Ltd., UK). [35]

Only the clasp assembly portion can be milled from the disc. The adhered surface of PEEK which are attached with the resin base can be treated by sand blasting with Al2O3 50-µm particles and after that conventional packing of heat cured resin can be done (Figures 3,4,5 and 6).[36]

Limitations

Acetal Resin Clasp

1. The force for removal is on lower side due its low modulus of elasticity.[37]
2. Acetal resin of pink shade can resist stress better than the white. For colouring acrylic, fibres which are rough in nature are added that mixed with the matrix, thus increasing the resistance to stress of the pink acetal resin. [38]

Peek Clasp [39]

1. Cost is on higher side than other materials

2. Tough chemical processing because of its low surface energy.

3. Advanced equipment (e.g., 5 axis milling) are needed for fabrication.

Conclusion

It is a challenging task to create proper esthetics as well as maintaining basic properties of a removable prosthesis i.e. support, stability, retention and preserving healthy tooth structure. Acetal resins and PEEK are highly multifaceted engineered products that match the difference of metals and plastics. Presence of metallic strength and flexibility of plastic, has made them a proper material for the fabrication of dentures, particularly the retentive element-clasps. These can be easily delivered to the patients who show allergic response to resins because these are monomer free. Acetal resin and PEEK material partial dentures offer a wide range of applications where metallic greyish color is absent, minimum tooth preparation is required as well as they transmit, minimum stresses on to the periodontally compromised abutments. Still further studies are required for modification and improvement of these materials.

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TABLES

Table No. 1

Properties of Acetal Resin	Properties of PEEK
Superior aesthetics. Higher abrasion resistance.	It has aesthetic resemblance with natural tooth colour and various particle reinforcement (graphene, carbon nanotubes) creates higher abrasion resistance
It is radiolucent and melting point (126°C) [40]	It is white, radiolucent, rigid material with great thermal stability up to 335.8° C [21]
High impact strength (69-122 J/m^2 at 23°C)	The highest impact strength was 5.7 kJ/m^2 for PEEK-pressed at 100 °C mold temperature and 4 kJ/m2 for PEEK-milled.[41]
Non allergenic, non-toxic. Clinically acceptable color changes after 300 hours of thermocycling	It is nontoxic, resistant to hydrolysis and has low plaque affinity – biocompatible [22,23]
High proportional limit with little viscous flow (enabling it to behave elastically over a large enough range to be used as a material for clasp fabrication) [3]	Peek is also having high proportional limit [42]
High elastic memory.	Semi crystalline Peek material has elastic memory.
Low thermal conductance.	Its thermal conductivity is less (0.25 W.m-1. K-1) [22]
Specific weight is low.	Low specific weight can be used to construct very lightweight prosthesis
Resistance to organic solvents, oils, alkalis, hot and cold water. Clinically acceptable color change after 300 hours of thermocycling [15]	Peek is bioinert material and it is resistant to degradation with various fluids. Resistance to sterilization process, using steam, gamma and ethylene oxide except concentrated sulfuric acid [22,23]
Low modulus of elasticity (2.9 to 3.5 kN/mm2) compared to Cobalt- Chromium alloys (Elastic modulus; 22.43 kN/mm2) – can be used in larger retentive undercuts.	Young's (elastic) modulus of PEEK is 3-4 GPa Flexural modulus of PEEK is 140-170 MPa [23,24]

FIGURES

Figure 1

Figure 2

Figure 3

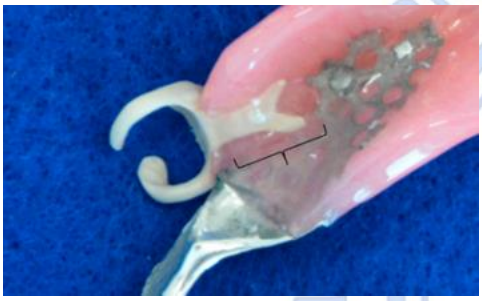

Figure 4

Figure 5

Figure 6