PEEK FRAMEWORK FOR REPLACEMENT OF POSTERIOR TEETH – A CASE REPORT

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Abstract

Materials used for fixed partial denture (FPD) frameworks have had properties of excellent strength,durability, and biocompatibility.Several materials have been used for fabrication of fixed partial denture such as alloys,ceramics, and high‑performance polymers. All these,though excellent, have their advantages and disadvantages.PEEK is a high impact polymer material that is made from fluorine benzene ketone, hydroquinone, and sodium carbonate or potassium carbonate, dissolved in diphenyl sulfone.PEEK can be blended with glass fibers or carbon fibers in order to enhance its mechanical strength. PEEK exhibits superior biocompatibility. It is non-mutagenic and nontoxic to human gingival fibroblasts and osteoblasts. Due to excellent properties of PEEK, it was used as framework for fixed partial prosthesis replacing posterior teeth. This case report describes the technique and fabrication of PEEK framework for FPD.

Keywords: PEEK, fixed partial denture, biocompatible, strength, success

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1. Introduction

Loss of teeth and associated structures leads to loss of function and probably a reduced quality of life of the subjects involved.[1]. Fixed partial denture has been an effective treatment modality for replacement of missing teeth when compared to other modalities for many decades.[2] The development of materials and technology in fabrication has been reported increased success rate and comfort for the patients. The first dental material that was used in fabricating fixed partial denture was gold by Etruscans. Later nickel and chromium were used for fabrication of framework. Due to increased demand with regards to aesthetics, veneering of the metal framework with tooth coloured material was introduced into dentistry. Ceramics are being used widely till date for metal ceramic restorations. Metal ceramic restoration are defined as an artificial crown or fixed complete or partial denture that uses a metal substructure and porcelain veneer.[3] Metal ceramic is a versatile material in fabrication of fixed dental prosthesis. [4] Fixed dental prosthesis is the most widely used restoration for replacement of the lost teeth [5] due to the results which indicate improved brain function with fixed dental prosthesis. [6]

CAD/CAM technology has improved the ease of fabrication and designing of the prosthesis. Even-though the all-ceramic restorations have been introduced, the metal ceramic restoration is considered a gold standard for posteriors. But the major drawback of metal ceramic restoration is exposure of metal and weigh more which sometimes causes discomfort in patients.The primary goal of prosthetic therapy is not only to replace lost teeth but also to rehabilitate the patient's occlusion. Replacement of missing teeth contributes to providing adequate masticatory efficiency, improving the patients phonetic and esthetic function. [7] Many research has been done in order to develop an alternative material for metal-based restoration. One such material that was introduced in dentistry is Polyether ether ketone (PEEK).

PEEK is a high impact polymer material that is made from fluorine benzene ketone, hydroquinone, and sodium carbonate or potassium carbonate, dissolved in diphenyl sulfone. PEEK consists of an aromatic nucleus linked by ketone and ether groups, providing it with a superior chemical stability that seems to be a double-edged sword.[8] PEEK exhibits excellent mechanical properties, including a low Young's modulus (3 to 4 GPa), which, compared to metal alloys (110 to 130 GPa), is closer to that of human cortical bone (14 GPa).[9] PEEK can be blended with glass fibers or carbon fibers in order to enhance its mechanical strength (i.e) glass fiber reinforced- and carbon fiber reinforced-PEEK (GFR-PEEK, CFR-PEEK) which exhibits greater flexural strength.[10] PEEK exhibits superior biocompatibility. It is non-mutagenic and nontoxic to human gingival fibroblasts and osteoblasts both in vitro and in vivo.[11] Due to excellent properties of PEEK, it was used as framework for fixed partial prosthesis replacing posterior teeth. This case report describes the technique and fabrication of PEEK framework for FPD.

Case Report

A 52-year-old male patient reported to the Department of Prosthodontics, SRM dental college, Ramapuram, Chennai, Tamilnadu, India, with the chief complaint of missing teeth in his lower back tooth region for past 2 years and wants a crown for root canal treated teeth in his upper back tooth. He apparentlyhad lost his teeth due to extraction done before 2 years due to extensive caries in his posterior teeth in mandibular arch. Patient had undergone root canal treatment before 6 months. The clinical examination and radiographic examination were done. The clinical findings showed that the patients had missing tooth in relation to 46 and root canal treatment in relation to 16 with generalized attrition in relation maxillary and mandibular arch. Radiographic examination of 16 revealed intact root canal treatment with proper peri-apical seal and temporary coronal seal **(Figure 1&2)**. The treatment plan for the patient was developed with the objective of restoring his oral health restoring his chewing function and esthetics with full veneered crown with PEEK framework.

Figure 1: Pre-operative frontal view

Figure 2: Pre-operative occlusal view

Procedure

The patient was informed about treatment plan and consent was obtained. The primary or diagnostic impression was made with irreversible hydrocolloid alginate impression material. The diagnostic cast was fabricated and articulated with a mean value articulator and diagnostic wax-up was done. An index was made using elastomeric impression material that is with heavy body (putty). The permanent coronal seal and core build up was done with composite restorative material in relation to 16. Tooth preparation of abutment teeth 45, 47 and root canal treated 16 was done followed by gingival retraction with size 000 cord. Definitive impression was made using elastomeric heavy body (putty) and light body impression material in a stock tray. The provisional restoration was fabricated with auto-polymerizing methyl methacrylate resin material and try in was done. The provisional restoration was cemented using temporary luting cement (non-eugenolbased cement).

The definitive master cast was fabricated from the impression with type 5 gypsum (diestone) material. The master cast was then scanned with extraoral scanner (densply, sirona) **(Figure 3)**. The coping for the fixed dental prosthesis was then designed in CAD software and converted to STL format. The coping was then 3D printed with SLA printer (Creality) **(Figure 4)**. The printed coping was flasked and subjected for burnout process which allows the 3D printed resin material to decompose at high temperature. Then 1g of PEEK material was measured with digital weighing scale and injected into the mould through injection moulding technique. As the density of PEEK material is very less (1.28–1.32 g/cm3), the coping obtained were very light in weight. The coping was then removed and excess was trimmed and surface was smoothened using tungsten carbide bur and polished with polishing disc. The PEEK coping was then checked intraorally in patient for marginal fit and occlusal clearance for further layering procedure **(Figure 5)**. After try in of coping, it was subjected for surface treatment with sulfuric acid with 98.08 MW% for 30 seconds to improve the bonding of PEEK material. The micro-retention beads helped in mechanical retention with the nanocomposite (Adoro). SRAdoro link was applied over the framework which acted as an adhesive. Nanocomposite called SR Adoro™ was layered andfired in the Lumamat 100 light furnace. The micro‑retentivebeads and the adhesive helped in the bonding of PEEK with Adoro composite material. The finished prosthesis with PEEKas its framework and Adoro layered over it was cemented with dual cure resin luting agent **(Figure 6)**. The evaluation of prosthesis after cementation was done and patient was recalled for review after 1 week interval, 1 month interval and 2 months interval. The prosthesis was intact without any distortion or complaint regarding fit and comfort. The patient's feedback regarding prosthesis was taken with few questionnaires which includes comfort of the prosthesis functionally and aesthetically. On clinical periodic recall of patient, the prosthesis was observed to be highly patient comfort, better in terms of strength withstanding the occlusal or masticatory forces and better in aesthetics.

Figure 3: Extra oral scanning of master cast and CAD designing of coping

Figure 4: 3D printing of coping design

Figure 5: Try In of PEEK coping

Figure 6: Post-operative view after cementation

2. Discussion

PEEK exhibits excellent mechanical properties, superior biocompatibility, metal free providing esthetic improvement. The PEEK has various application in dentistry especially in field of prosthodontics. Various applications of PEEK include retentive components for removable prosthesis, base framework replacing metal base removable prosthesis, framework for fixed partial dentures, abutments for implant, healing cap or screw for proper emergence profile in implant prosthetic treatment, post and core restoration, recently due to its excellent biocompatibility and mechanical properties PEEK has been used for implant manufacturing.

Finite-element analysis (FEA) of carbon-fiber reinforced PEEK (CFR-PEEK)implants suggested that they could induce lesser stress shielding than titanium.[12]Animal studies have suggested that PEEK can survive for up to 3 years while inducing non-remarkable localized inflammation. [13] Randomized controlled clinical trial (RCT) conducted by Koutouzis et al.suggested that there is no significant difference in the bone resorption and soft tissue inflammation around PEEK and titanium abutments.The oral microbial flora attachment to PEEK abutments is comparable to those made oftitanium, zirconia and polymethylmethacrylate. A study done to evaluate the fracture resistance of the CADCAMmilled PEEK fixed dentures concluded that PEEK has fracture resistance much higher than those oflithium disilicate glass-ceramic, alumina, zirconia.[14] A randomised control trial done by Beretta et al comparing the CAD-CAM fabricated PEEK healing abutments and standard healing caps on emergence profile at the surgical stage and it was concluded that the PEEK healing abutments showed higher efficiency, favourable emergence profile and better as well faster healing period. [15] The major drawback of PEEK is adhesion of the material; thus, surface treatment is required in order to improve the bonding and favorable outcome. Various surface modification methods and adhesion techniques have been applied such as acid etching, sandblasting, laser treatment, adhesive systems, plasma treatment. In order to increase the wettability and improve bond strength surface treatment with sulfuric acid are used and study done by Escobar et al found that 98% sulfuric acid etching along with acidic adhesive for 0,1,3,5 min showed higher wettability and increased shear bond strength of PEEK which was supported by similar study done by Ma et al. On microscopic analyses, it was found that when acid etching is performed micro to nano scaled pores are formed that forms a complex network to which the adhesive material flows and bonds well to the PEEK material improving the bond strength.[16,17] Resin luting cement, comprising universal resin cements and self-etch resin cements, has provided promising adhesion improvements for PEEK. studies have shown that combining resin luting cementwith sulfuric acid etching is an excellent strategy for enhancing PEEK's bonding behavior,with universal resin cements such as RelyX ARC and Variolink II showing better bonding behavior than the self-adhesive resin cement regardless of the duration of the sulfuric acid etching.[18] In this present case report, the microcrystal granules provided the mechanical retention and SR Adoro Link helped in chemical retention for the nanocomposite which was used as a layering material over the PEEK framework.The low density made the prosthesis very light in weight. Comparatively, the amount and weight of pellets which would have been required for casting the same framework in Ni–Cr would have been much higher. PEEK has a glass transition temperature of around 143°C and melting temperature of 343°C. It is highly resistant to thermal degradation and to attack by both organic and aqueous environments.

3. Conclusion

The evaluation of prosthesis after 1 week interval, 1 month interval and 2 months interval showed minimal plaque accumulation and healthy gingiva around the abutment teeth. The patient was comfortable and satisfied with the prosthesis. The FPD was intact and showed better strength and functional capability supporting the fact that PEEK serves excellent replacement for metal as FPD framework. Although the technique is sensitive and equipment oriented.

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