Case Report

PEEK framework for full-mouth rehabilitation with fixed, implant-supported prostheses: a case report

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Abstract

An implant-supported complete arch fixed prosthesis is a viable treatment option for edentulous patients, and the stress distribution from the framework to the implant and peri-implant bone has been discussed.[1,2] Titanium or zirconia framework has a higher Young's modulus compared to polyetheretherketone (PEEK), while the tensile properties of PEEK are similar to human bone, potentially providing a shock-absorbing capacity.[3-5] However, the low Young's modulus of the PEEK may introduce greater deformation and micro-motion at the implant-bone interface.[4-6] This clinical report presents a full-mouth rehabilitation case utilizing PEEK as an implant framework material with zirconia crowns and composite resin for artificial gingiva. While PEEK is a promising framework material, it still lacks long-term clinical evidence, and further investigation is necessary before recommending its use as a non-metallic material.

Key words: polyetheretherketone (PEEK), full-mouth fixed implant-supported prostheses, veneering composite resin

Introduction

Polyetheretherketone (PEEK) is a synthetic, polymeric material that has possess unique physical and mechanical properties and can be easily modified by incorporating carbon fibers or glass fibers.[4,5] It is one of the Polyaryletherketones(PAEKs) polymer group family and the chemical structure of polyaromatic ketones confers stability at high temperatures and compatibility with many reinforcers.[4,7,8] PEEK has been proposed for a number of dental applications.[3,6,9-11] Another PEAKs family material named PEKK shares a similar chemical structure with PEEK, but replaces one of the flexible ether linkages with a more rigid ketone group, and the second ketone group is selected ortho(straight) or para(kinked) substituted.[7,8,10] Different companies have manufactured proprietary materials that contain a variety of reinforcers, such as ceramic fillers, and with patented formulations and processing protocols provided. For example, JUVORA™ PEEK(JUVORA™ PEEK, Invibio Ltd, Leeds, United Kingdom) and BioHPP (BioHPP, Bredent, Senden, Germany) were declared as products derived from PEEK and Pekkton ivory (Pekkton ivory, Cendres+Metaux SA, Bienne, Switzerland) was declared developed from PEKK. This case report describes the case using PEEK as framework material for a full-mouth implant-supported fixed rehabilitation.

Case Report

In August 2013, a 50-year-old female patient came to the Department of Prosthodontics of Taipei Medical University Hospital seeking evaluation for full-mouth fixed restoration. After a comprehensive examination(Fig. 1 and Fig. 2), the patient's remaining teeth were found in devastating conditions. All teeth showed severe bony destruction and mobility grade three(Miller's classification 1953)[12], the diagnosis was generalized periodontitis stage IV grade C(Staging and grading of periodontitis, Tonetti 2018)[13], and the prognosis of every single tooth was determined as hopeless(McGuire prognosis 1996)[14]. Based on cephalometric analysis, the patient had an Angle Class III malocclusion (bilateral Class III canine relationship, Angle's classification1890, and BO located ahead of AO, Wits analysis 1975) (Fig. 3)[15-16], which may compromise the clinical performance of the upper anterior implants with a conventional implant-supported "crown and bridge" design. The patient denied any drug or food allergies, had an unremarkable medical history, and denied any parafunctional habits. A fixed restoration was the only option to meet the patient's expectations, and well-established data collection was performed to assess the feasibility of implantation. After a detailed discussion, it was decided to extract all teeth that could not serve as fixed abutments due to generalized loss of periodontal support and the poor crown-to-root ratio.[17,18] The patient's residual ridge was a combined defect and was categorized as LTR Class IV.[19] The number, position, and angulation of implants were considered, and all viable treatment modalities were discussed with the patient. Finally, the definitive prosthetic treatment plan included fixed dental prostheses for both upper and lower arches, each supported by eight implants. The prosthetic design was a hybrid prosthesis, including a PEEK framework, zirconia crowns, and light-curing composite resin for the gingiva portion.

Due to the etiology stemming from periodontitis, the treatment began with disease control, followed by extraction of all hopeless teeth under sedation. Immediate dentures made by complete denture protocol were fabricated and delivered (Fig. 4). Three months later, a preliminary impression (Cavex Cream Alginate, CAVEX GmbH, Ofterdingen, Germany) was taken. Diagnostic wax-up and surgical stents were made for implants (Astra Tech Implant System TX, Dentsply Sirona, Charlotte, USA) insertion. A final impression was made with polyvinylsiloxane impression material (Aquasil, Dentsply Caulk, Charlotte, USA) and customized individual trays (Plaque Photo, Willmann & Pein GmbH, Barmstedt, Germany) after the implants achieved osseointegration(Fig. 5). Then, the implant-supported baseplates and wax rims were made for centric relation record and to determine vertical dimension and lip support. The uni-abutments (Astra Tech Implant System TX Uni Abutment, Dentsply Sirona, Charlotte, USA) were selected according to the working casts and titanium temporary cylinders were used to make verification jigs. These jigs were then used to verify that the implant positions were coincident with the analogues in the working cast by one-screw test (Fig.6). Mandible flexure was taken into consideration[20], and the lower implant-supported fixed prostheses was divided into two pieces between 43 and 44. Once the positions of the analogues were confirmed, the full-contour resin patterns (Tempron, GC Dental Products Corporation Kachigawa Plant, Kasugai-shi Aichi, Japan) were fabricated and used for clinical try-in. Afterwards, the full-contour resin patterns were cut back for the prototype of definitive frameworks. PEEK (BioHPP, bredentUK, Chesterfield, UK) was used as the final framework material, which was fabricated by a 2-press system method (Fig. 7). The prototypes were duplicated as wax patterns, which were invested and heat pressed following the instructions provided by manufacturing company(Fig. 8 and Fig. 9). The framework try-in was performed and checked both intraorally and radiographically. The passive fit of the framework was confirmed by one screw test and cleanability was also examined. Acrylic resin crowns (Tempron, GC Dental Products Corporation Kachigawa Plant, Kasugai-shi Aichi, Japan) were try-in and adjusted for optimal contours and occlusion, and used as templates for CAD/CAM permanent zirconia crowns (Ceramill CAD/CAM material, AMANN GIRRBACH, Koblach, Austria) (Fig. 10 and Fig. 11). Nano-filled light-curing composite resin (visio. lign, bredent UK, Chesterfield, UK) was applied for the artificial gingiva(Fig. 12). The surface treatment included bonding agent usage (SR Link, Ivoclar, Schaan, Liechtenstein). The framework was delivered with 15N torque, and the zirconia crowns were cemented with temporary cement, which was recommended by the manufacturer (Temp-Bond, Kerr, California, USA) (Fig. 13) (February 2016). Throughout the following years' follow-up, the full-mouth implant-supported fixed prosthesis worked functionally.

Figure 1. Initial intra-oral examination showed severe periodontitis.

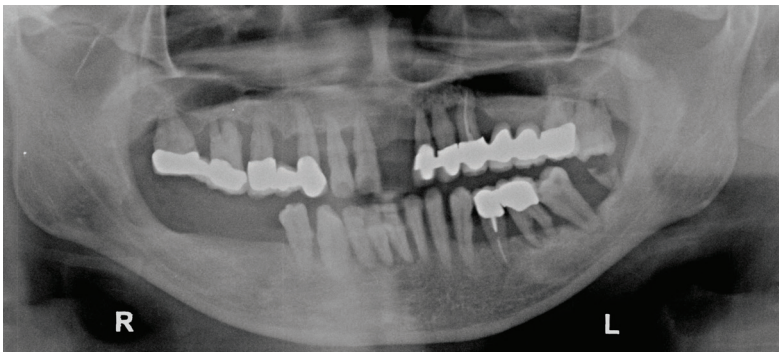

Figure 2. The panoramic film showed remaining dentition with severe bony destruction.

Figure 3. The cephalometric analysis indicated that the patient was Angle's Class III malocclusion.

Figure 4. Immediate dentures were fabricated and delivered.

Figure 5. Upper and lower implants with healing abutments (Astra Tech Implant System TX, Dentsply Sirona, Charlotte, USA).

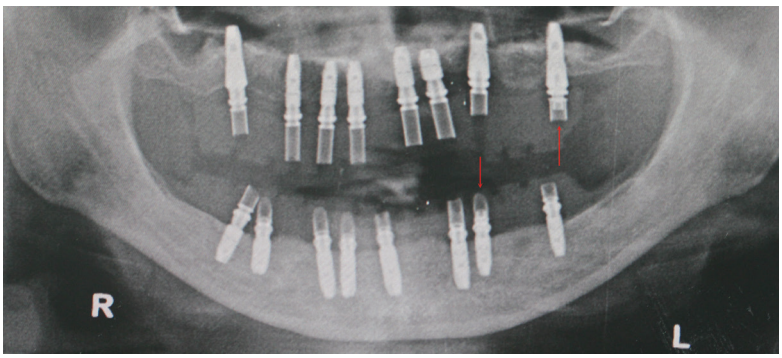

Figure 6. A panoramic film was taken for examination by one-screw test, and the arrows indicate the temporary cylinders with screws.

Figure 7. The PEEK framework was fabricated by a 2-press system method.

Figure 8. The wax patterns were used for investment and followed by the heat pressing procedure.

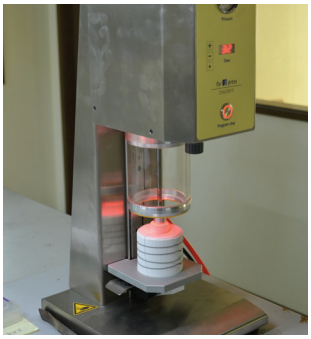

Figure 9. The heat pressing machine. (For2Press^{R} System, bredent UK, Chesterfield, UK)

Figure 10. Permanent zirconia crowns were fabricated by CAD/CAM technology.

Figure 11.
Try-in of the permanent zirconia crowns on the PEEK framework.

Figure 12.
The artificial gingiva was made of nano-filled light-cured composite resin (visio.lign, bredent UK, Chesterfield, UK).

Figure 13.
Follow-up image of the implant-supported full-mouth fixed prostheses.

Discussion

It is known that Young's modulus and tensile properties of PEEK are similar to those of human bone.[3-5] Therefore, PEEK is considered to have a potential shock-absorbing capacity.[3] Han used Pekkton (Pekkton ivory, Cendres+Metaux) as an implant framework, indicating acceptable esthetic and functional results.[21] Zoidis published clinical reports utilizing PEEK implant frameworks and concluded it could be an alternative treatment.[22] Nobre published a three-year follow-up article, using PEEK as a framework in a fixed implant- supported prosthesis in conjunction with the all-on-four concept, which achieved a high prosthetic/ implant cumulative survival rate and patient satisfaction, with lower marginal bone loss and low incidence of biological complications.[3] Similar findingswere found in research published in 2018.[23]

Mechanical complications mainly occur in patients with bimaxillary rehabilitations, with implant-supported fixed prostheses in the opposing arch.[3] Although the rigidity of titanium or zirconia may cause stress concentration[24], on the other hand, the low Young's modulus of the polymeric frameworks and longer lever arms cause greater deformation and micro-motion at the implant-bone interface. Yu in 2022 suggested that zirconia and metal resulted in a more favorable distribution of stress in implants and supporting bone than polymer in a fixed implant-supported mandibular prosthesis.[6]

Research indicated a stiffer framework provides a more even distribution of forces among the bridge and abutments, decreasing the stress within the retaining screws as a result of reduced bending of the framework.[1,6] The relevant conclusions are based on finite element analysis while the clinical reports, which took advantages of PEEK, still lacked long-term follow-up.[3,5,22,23]

Another issue is the bond strength between composite resin and PEEK, which Nobre considered part of the learning curve in the manufacturing process.[3] In 2019, Jin compared BioHPP and titanium framework, and the result showed that the shear bond strength between BioHPP and composite resin is significantly higher than that between titanium and composite resin.[25] To increase the bond strength between composite resin and PEEK, Gouveia used airborne-particle abrasion with 110-μm aluminum oxide for surface treatment, which could increase the shear bond strength between veneering composite resin to PEEK and PEKK polymers and indicated the manufacturing process (milled or heat-pressed) did not significantly affect the bond strength.[26] Taha suggested combining airborne-particle abrasion with laser or plasma treatment to increase adhesion ability.[27]

Summary

The accuracy and mechanical properties are key to full-mouth fixed implant-supported prostheses. Considering the unique characteristics of PEEK[3-5,23], using this material for framework in full-mouth implant-supported rehabilitation appears to be a feasible alternative option. However, long-term studies are needed before recommending this protocol.

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