



# USE OF MODIFIED POLYETHERETHERKETONE IN IMPLANT PROSTHODONTICS:

## PART #1

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**A METAL-FREE  
AND STRESS BEARING ALTERNATIVE  
FOR FIXED IMPLANT SUPPORTED  
PROSTHESIS.**



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# INTRODUCTION



Polyetheretherketone (PEEK) is a semicrystalline, organic polymer obtained by step-growth polymerization by the dialkylation reaction of bisphenolate salts.<sup>(1)</sup> It is a high-temperature thermoplastic polymer consisting of an aromatic backbone molecular chain interconnected by ketone and ether functional groups.<sup>(2)</sup>

Because of its mechanical and physical properties being similar to bone and dentin, PEEK can be used for a number of applications in dentistry including fixed crowns and bridges, removable dentures and several other applications in implant dentistry. Polyetheretherketone is of great interest as an alternative material to titanium in oral implantology because of its biocompatibility and low elastic modulus (Table 1). Other good mechanical properties include its high melting point (about 335°C), easy processing, high stiffness, good dimensional stability at high temperature and it is chemically stable to nearly all organic and inorganic chemicals. In addition, PEEK shows resistance to radiation damage and compatibility with many reinforcing agents such as carbon fibers or ceramic fillers.<sup>(3)</sup>

Ceramic reinforced modified-PEEK can be fabricated either by computer aided design and computer-aided manufacturing (CAD/CAM) or by compression-molding, and can be used as a framework material for fixed or removable implant prostheses. The white color of the PEEK framework, in combination with veneering resin composite material, permits the fabrication of metal-free restorations with improved esthetic appearance compared with conventional metal-based prostheses.

Although further research and clinical trials are required to explore this material, modified PEEK is an attractive and promising material for producing CAD/CAM implant supported prostheses.

This article presents the prosthetic rehabilitation of two patients with extended edentulous spaces where dental implants were strategically placed to support the fixed prosthesis. Instead of conventional titanium or zirconia, modified PEEK in CAD/CAM blocks was chosen as the framework material (Tecno Med Mineral, Zirkonzahn). Also, custom-designed ceramic layered lithium disilicate crowns were made (e.max Press MT, Ivoclar Vivadent) and bonded to the framework in order to optimize the esthetic results and if necessary, to make replacement easier in the future. Finally, pink veneering indirect laboratory composite (Crea.lign, Bredent) was applied to naturally reproduce the gingival anatomy of each masterpiece.

# CASE 1

A 45-year-old woman presented with failing full acrylic fixed implant-supported prosthesis to the Department of Prosthodontics and Implant Dentistry at Universidad de La Salle Bajío. The patient referred that she had been wearing the prosthesis unsatisfactorily for the last two years. She was in good general health, and her medical history was noncontributory. Her chief complaint concerned the unnatural and compromised esthetic appearance of her smile, and difficulty with chewing and function. Initial intraoral and extraoral clinical assessment (**Figs 1 to 3**) revealed the incorrect design and poor condition of the prosthesis, which was supported by three osseointegrated implants in good condition (located at the site of the right upper second molar, the upper right first premolar and the upper left central incisor) with a distal cantilever corresponding to the edentulous space of the canine and the upper left lateral incisor. This edentulous space revealed a Seibert's Class I bone defect, which made subsequent implant placement impossible (**Fig. 4**).

A horizontal alveolar bone augmentation and subsequent implant placement in the site of the left maxillary canine were performed in order to optimize the implant distribution in the extended edentulous space.

Based on the clinical and digital assessment (radiographs and CBCT Scan), the patient's functional/esthetic requirements and financial aspects, a definitive CAD/CAM screw-retained implant-supported prosthesis was proposed and accepted by her.



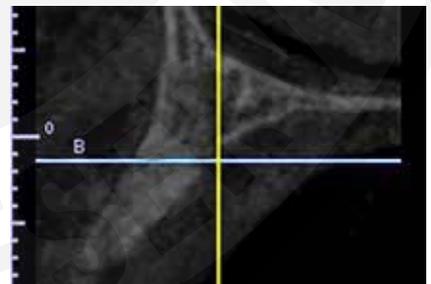
**Figure 1.** Baseline situation. Preoperative extraoral image showing the preexisting prosthesis and the unpleasing aspect of the patient's smile.



**Figure 2.** Preoperative intraoral frontal view.



**Figure 3.** Preoperative intraoral lateral view showing the incorrect and overcontoured prosthetic design.



**Figure 4.** CBCT image. Sagittal section corresponding to the maxillary left canine edentulous space.



**Figures 5a to 5d.** Functional and esthetic evaluation. Screw-retained diagnostic prototype wax-up according to the esthetic analysis conducted <sup>(14)</sup>. It also provides to the patient the previsualization of the design of the transitional and definitive prosthesis.



**Figures 6a to 6e.** The definitive diagnostic wax-up prototype was completed taking into consideration all the esthetic parameters and was scanned (S600 Arti Scanner, Zirkon Zahn) for the accurate fabrication of a CAD/CAM screw-retained implant-supported transitional prosthesis.





*Figures 7a and 7b.* The CAD/CAM transitional prosthesis was milled in a high-performance and long-lasting PMMA material (Temp Premium, Zirkon Zahn).



*Figures 8a and 8b.* Pink veneering laboratory composite was applied to reproduce the gingival anatomy of the CAD/CAM transitional prosthesis (Crea.lign, Bredent GmbH & Co.kg).



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**Figure 9.** Smile view with the CAD/CAM transitional implant-supported prosthesis following incorporation. This transitional phase is necessary when a fixed implant-supported prosthesis is planned. During this time, the soft tissue of the edentulous space needs to be conditioned through the flattened or convex intaglio surface of the fixed prosthesis. This will allow a cleansable design of the definitive restoration.



**Figures 10 and 11.** The patient tolerated the transitional prosthesis well over a period of approximately 10 months. After this time, final impressions with PVS material and maxillomandibular records were taken to subsequently obtain the definitive working models.

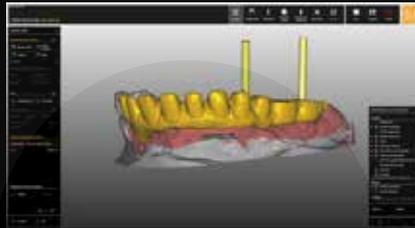
Figures 12a to 12c.



12 a. The working model with the final screwed attachments.

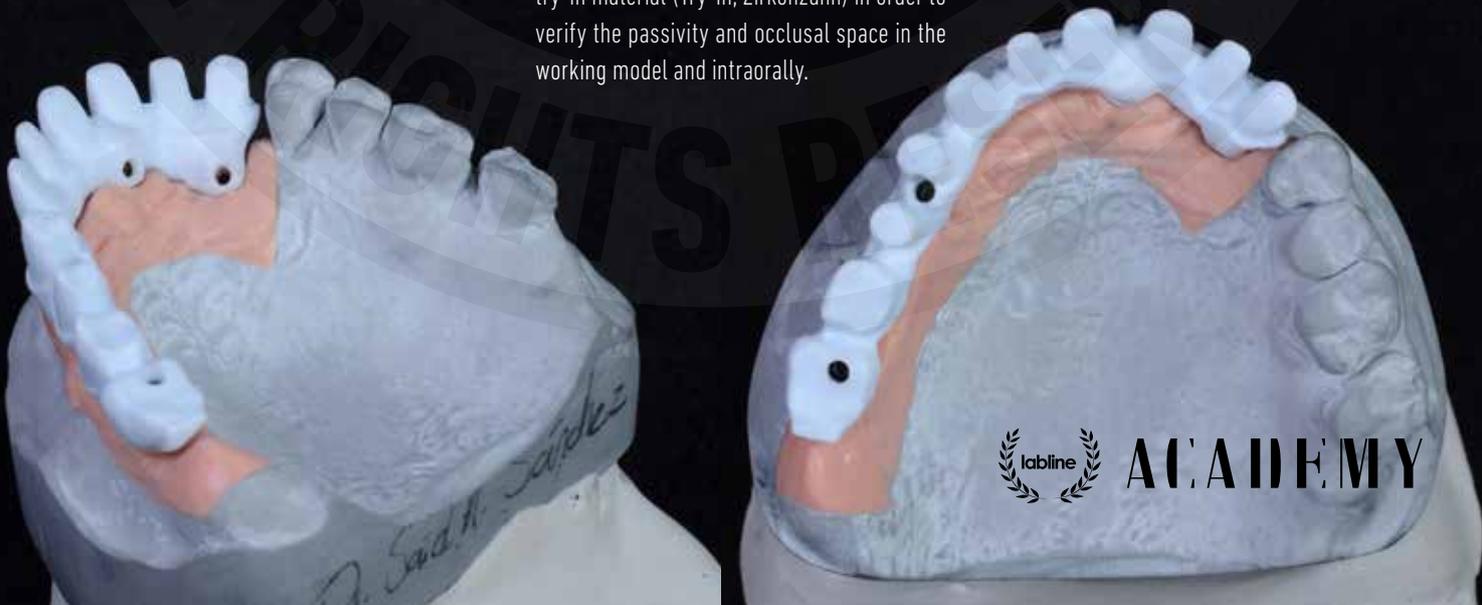
12 b. A horizontal screw retention system (Security-Lock, Bredent GmbH & Co.kg) was used to fabricate the definitive abutments of the maxillary anterior implants on high-gold content alloy (Harmony Extra Hard, Ivoclar Vivadent). This will prevent the implants' emergence towards the anterior teeth's incisal edge in the definitive prosthesis.

12 c. Verification of adequate entry and fit of the screw onto the attachment.

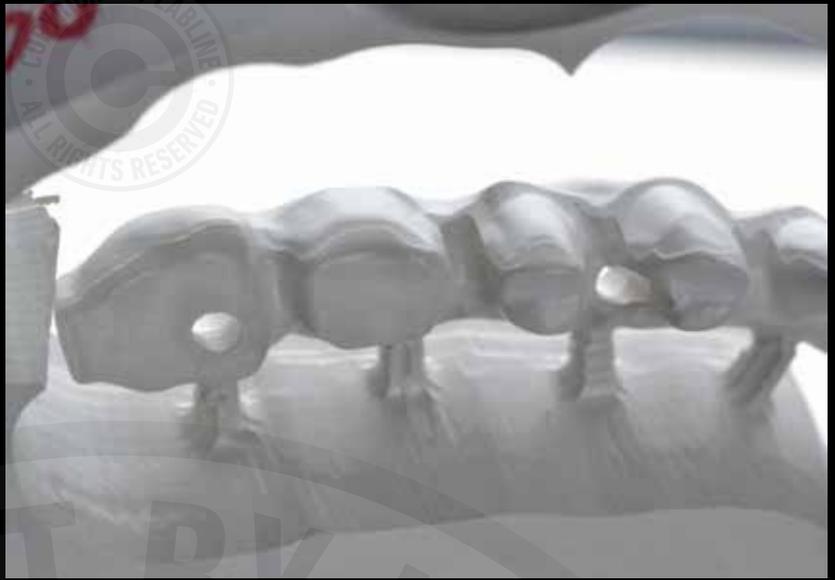


Figures 13a to 13c Scanned image of the working model with the definitive attachments and subsequent framework design in modified PEEK material.

Figures 14a and 14b. The maxillary framework was first milled in a rigid resin try-in material (Try-in, Zirkozahn) in order to verify the passivity and occlusal space in the working model and intraorally.



**Figures 15 and 16.** The maxillary modified-PEEK framework was milled using the prototype wax-up as a reference to create the adequate reduction to receive the subsequent custom-design ceramic crowns.



**Figures 17a to 17c.** Burn-out resin material (Try-in & burnout, Zirkonzahn) was used to produce CAD/CAM individual copings. Afterwards, a full-contour wax-up was applied to each one and tried intraorally.



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**Figures 18a to 18c.** Full-contour monolithic lithium disilicate glass ceramic crowns were obtained using the pressing technique with a minimal cutback (IPS e.max Press, Ivoclar Vivadent).



**Figures 19a to 19d.** All the monolithic lithium disilicate crowns were cleaned and prepared for feldspathic porcelain application (IPS e.max Ceram, Ivoclar Vivadent).





*Figures 20a to 20c.* Lithium disilicate all-ceramic crowns after porcelain veneering.



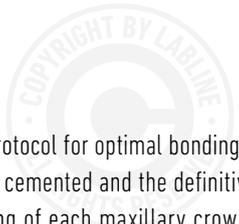
*Figures 21a and 21d.* Try-in of the ceramic restorations on the modified-PEEK framework.





**Figure 22.** Finished anterior restorations after polishing and glazing. A final high-gloss polish was carried out with diamond polishing paste and soft brushes.





**Figures 23a to 23c.** Modified-PEEK surface conditioning protocol for optimal bonding, as shown in table 2 (15, 16). Following this protocol, the ceramic crowns were cemented and the definitive attachments were added to the superstructure. Ceramic surface conditioning of each maxillary crown was accomplished following the protocol described in **Table 3**.



**a.** Surface modification of modified-PEEK framework with airborne particle abrasion.



**b.** The remaining particles were removed using compressed air. A steamer should not be used.



**c.** Framework surface priming with a thin layer of light-curing bonding agent (Visio.link, Bredent GmbH & Co.KG)

Material	Tensile strength (MPa)	Young's modulus (GPa)	References
PEEK	80	3-4	(4)
CFR-PEEK	120	18	(4)
PMMA	48-76	3-5	(5,6)
Titanium	954-976	102-110	(7)
Cortical bone	104-121	14	(8,9)
Enamel	47.5	40-83	(10,11,12)
Dentin	104	15	(11,13)

**Table 1.** The tensile strength and elastic moduli of PEEK and carbon reinforced PEEK compared with other materials and mineralized human tissues.

Step 1	Modified-PEEK surface must be sandblasted at a pressure of 2-3 bar using 110 microns aluminum oxide.
Step 2	Use compressed air in order to remove remaining particles. Do not use the steamer.
Step 3	Priming the PEEK surface with a thin layer of light-curing bonding agent.
Step 4	Polymerized subsequently in the light polymerization unit (wavelength range of 370-400 nm) for 90 seconds.

**Table 2.** Modified-PEEK surface conditioning protocol for optimal bonding.





*Figures 24 to 27.* Different views of the completed laboratory work. Definitive restoration ready for insertion.





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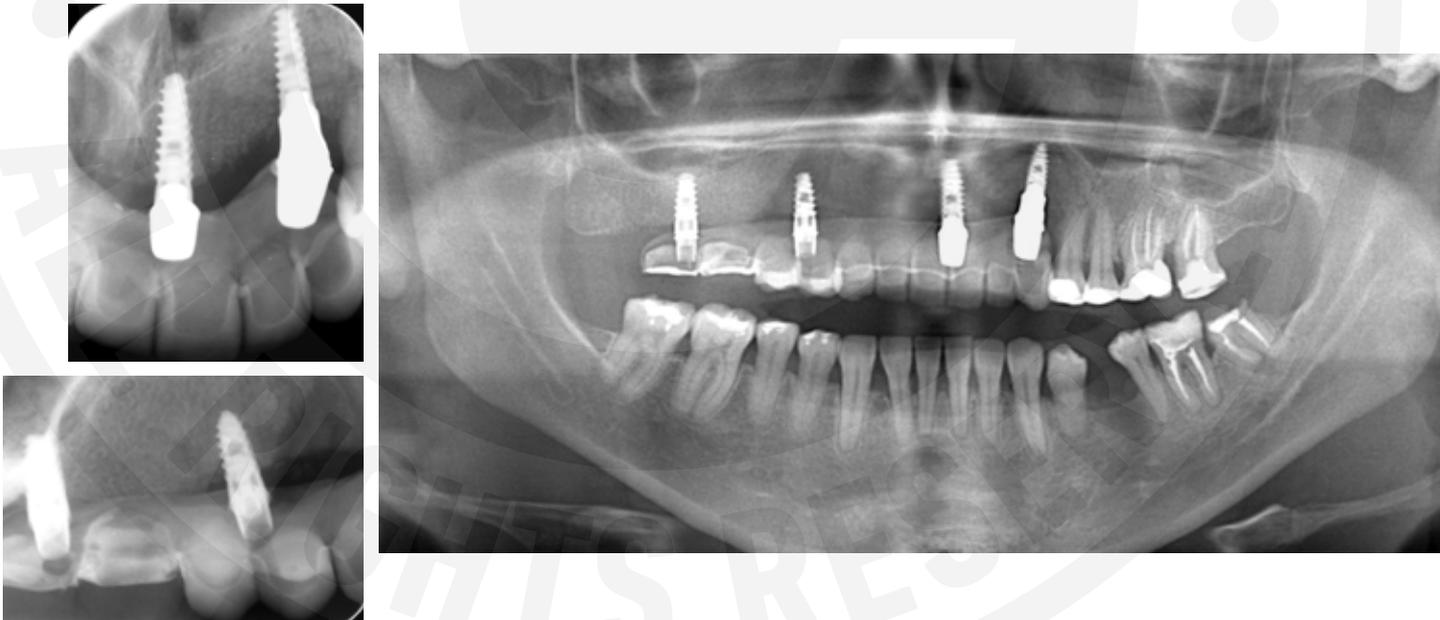


**Figure 28a** Portrait photograph. Fixed implant-supported prosthesis immediately after it was screwed into place.



**Figure 28b.** Final extraoral close-up view.

**Figures 29a to 29c.** Final radiographs after eight months.



**...TO BE CONTINUED**



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