# High-performance polymers - part two

In the second article in this series, **Professor Paul Tipton** and **Dr Bernd Siewert** look at Polyether ether ketone (PEEK) - a new material for framework fabrication - and consider the processing methods, pressing vs milling and the findings regarding long-term use

Polyether ether ketone (PEEK) highperformance polymer has proven successful in many areas of medicine for a number of years and is also gaining an ever-increasing number of advocates in dentistry thanks to its good physical properties and chemical resistance. CAD/CAM processing of PEEK also opens new options. In the following article the authors demonstrate the

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Dr Bernd Siewert studied at the Christian Albrecht University, Kiel, Germany from 1981 to 1986. He spent his two-year assistance time in a practice near Hamburg, Germany. In 1989 he gained a Dr. med. dent. doctorate before moving to Spain where he worked in private practice in Madrid and Malaga. Since 1996 Dr Siewert has his own private practice in Madrid and specialises in implant treatment. Since 2007 he has worked as an instructor at the International Training Center for Dental Implantology (IFZI), Nuremberg, Germany, lectures at a national and international level and is the author of numerous publications.

possibility of milling PEEK in the CAD/ CAM procedure from industrially manufactured material blocks (Juvora dental disc) rather than injection moulding, and present long-term documentation of a case involving treatment of bruxism by means of a prosthetic restoration.

## Injection-moulding technique

If industrially manufactured elements are used for an implant-borne prosthetic restoration they can be overmoulded (thermopress system) with PEEK. This eliminates the need for additional adhesive retention, which can be of particular advantage where little space is available, for example in the anterior region. Furthermore, the injection-moulding technique requires lower financial investment than CAD/CAM fabrication of PEEK frameworks.

The entire fabrication process of wax-up, investing and finishing is time consuming. The procedure with the thermopress system was not fully developed technically. In some cases visible voids and cracks were produced in the framework due to the familiar problems of injection moulding. In these cases the complete fabrication process had to be repeated. It was not always possible to maintain the surface contours of the wax-up exactly due to adjustments to the surface which were occasionally necessary. This is counter productive, in particular with fully anatomically designed bridge frameworks.

The transition to the plastic phase (heating and subsequent cooling) impairs the material-technical properties, especially with high-performance polymers such as PEEK. There is the risk of changes in the crystal lattice structure. Despite these factors, which may result in a reduction in quality, no problems with regard to crack formation, material fatigue or even fracture have occurred.

## CAD/CAM bridge frameworks

Industrially manufactured blanks with approval for permanent restorations have recently become available (Juvora dental disc, Juvora). This material has no additives - it is therefore highly pure - and has been used in medicine for many years (PEEK-OPTIMA, Invibio).

The advantage of CAD/CAM fabricated bridge frameworks is that the material is not adversely affected during the fabrication process, provided it is used correctly. Bridge frameworks, milled from a high-grade, industrially manufactured block (Figures 1-2), undergo no physical changes during the fabrication process and exhibit the same or possibly better material-

#### Aims and objectives

To discuss the properties of PEEK polymers as used in a milled restoration designed by CAD/CAM to treat a bruxism patient.

#### **Expected** outcomes

Correctly answering the CPD questions on page 88 shows that the reader has understood how the properties of PEEK materials can be best applied for dental applications.

Verifiable CPD hours: 1





Figures 1-2: Framework (left: basal, right occlusal), Juvora dental disc fabricated in the CAD/CAM supported process

technical properties (Figures 3-4). Advantages of CAD/CAM:

- High-quality bridge frameworks with no material faults
- Precise manufacture
- Reduced manufacturing time
- Easily reproducible fabrication process. The reworking required is limited to

high-lustre polishing, provided a correct CAD/ CAM chain is employed. This guarantees that the shape contoured during softwaresupported fabrication is retained exactly.

#### **Bruxism in patients**

In our opinion the ideal method and materials have yet to be found in the search for an optimal prosthetic solution for bruxism patients. Acrylic teeth have a damping effect but are subject to abrasion. Metal or all-ceramic restorations are at risk of fracture and do not provide any shockabsorbing effect to prevent overloading of the patient's natural teeth and the implants.

## **Prosthetic restoration**

This 55-year-old female patient, was referred to us for implant treatment and prosthetic restoration (Figure 5). She had previously been treated via a bar-supported denture placed on four implants (Figures 6-9).

After 13 years of use the overdenture was damaged due to severe bruxism and was no longer sufficient. It was replaced by a fixed, operator-removable, horizontally screwretained bridge (Figures 10-12). The chrome-cobalt-molybdenum alloy telescope crowns on four implants and two molars were adhesively retained in a bridge framework fabricated using PEEK (BioXS, Bredent).



Figure 3: The veneered bridge on the master model (palatal view)



Figure 4: The bridge in the patient's mouth after ten months in situ. The secondary telescope UL6 and bridge pontic UL5 have been designed fully anatomically. The shade of the non-veneered PEEK (Juvora dental disc) is acceptable for the occlusal surface in the posterior region. The gingival conditions are excellent



Figure 5: Initial situation, partially edentulous upper jaw with retained and displaced canines



Figure 6: After removal of the canines and placement of four implants







Figures 7-9: At the time (1996) the patient was prosthetically treated with a bar-supported denture











Figures 10-12: After 13 years the damaged denture was replaced by a fixed, operator-removable, horizontally screw-retained bridge

Figure 15 (right): Neither the implants nor the molars (primary crowns) show any clinical anomalies

Figures 13-14: After three years in situ the veneers split off again (bruxism), the PEEK frameworks, however, show no signs of impairment



After three years in situ the occlusal surfaces (veneers) had been abraded completely in the posterior region and later the veneers split off tooth UL2 due to the bruxism (Figures 13-14). A remake of the prosthetic restoration was unavoidable. The BioXS PEEK framework material was completely intact. Following abrasion of the acrylic teeth, the framework surface was in direct occlusal contact and there were only minimal signs of wear. No cracks or decementation were observed basally. Neither the implants nor the molars with the cemented primary crowns showed any clinical anomalies (Figure 15).

What appeared to be clear was that the composite bridge design of the PEEK bridge framework is also sufficiently resistant to withstand enormous masticatory forces, but that the acrylic teeth in the posterior region are the weak point in patients with bruxism.

# Second prosthetic restoration

It was then decided on CAD/CAMsupported fabrication of a fully anatomical bridge framework for the remake of the prosthetic restoration. The material used was unfilled PEEK, Juvora dental disc, which can be used for fabricating highly precise restorations. The basal region was designed fully anatomically in a convex shape (Figures 16-19). The buccal aspects in the visible areas from premolar to premolar were veneered. As both the protrusive and lateral excursions were to be on the PEEK framework, no prefabricated laminate veneers were placed in this area but rather custom-milled composite veneers (Figures 18-19). The occlusal surfaces and guidance

pathways were not veneered.

An occlusal screw-retained restoration was fabricated as horizontal screw retention in combination with the telescope principle can be problematic from a hygiene point of view. To ensure that the bridge fitted passively, the four implant copings in the mouth were adhesively retained and then the new restoration fitted. The nonveneered Juvora dental disc is barely noticeable as an occlusal surface material. The grey-brown shade of the occlusal and oral sections was accepted by the patient without any problem (Figures 20-21).

In such cases where bruxism is a problem the focus is on producing a durable, functioning restoration. The shockabsorbing properties of the new design should protect the implants and the patient's natural teeth against the destructive forces of bruxism. Juvora dental disc PEEK material is completely free of additives (eg barium sulphate) and is therefore not visible on

anorthopantomogram; a detail that one has to become accustomed to (Figure 22).





Figures 16-17: The implant-supported bridge was remade with CAD/CAM



Figures 18-19: The finished bridge. The Juvora dental disc framework was designed fully anatomically in the functionally critical areas





Figures 20-21: Finished bridge in situ



Figure 22: The X-ray image. The Juvora dental disc is highly pure and free of additives, and is therefore not visible on the X-ray

## Discussion

Invibio Optima PEEK has been tried and tested as a material for implants in the medical field for over ten years. Its high biocompatibility has been proven in several clinical studies (Siewert, 2013). The low specific weight, bone-like elasticity, metal-free character and toughness, combined with virtually non-existent material fatigue make it an ideal material for use in prosthetic dentistry. The CAD/CAM-supported processing of PEEK opens up new possibilities. The physical properties of the material described allow approximately the same design dimensions as those of metallic materials.

To date, approval of the Juvora dental disc covers removable restorations, implant-borne prosthetics and crowns and bridges. This means that cast-metal denture bases, secondary units, superstructures with fixed/removable restorations, implant-supported, posterior full crowns and (as demonstrated here) operator removable, screw-retained bridges can be fabricated using the material described. In the past, long-term clinical results were achieved in patients with bruxism and heavy pressing using a gold alloy on the occlusal surface. A material is now available for these indications, which has the effect of damping masticatory forces and, due to its greyish shade, can also be used for occlusal contours - metal free and biocompatible.

## Conclusion

The positive clinical experiences using fully anatomical PEEK bridge frameworks, fabricated using the injection-moulding technique, can be transferred to CAD/CAM processing. This enables frameworks to be fabricated in a reliable, reproducible production procedure.

Consistent, optimum material quality is also guaranteed. The chemical properties of PEEK exclude any transparent versions. However, it may be possible in the future to add inorganic dyes to reproduce the shades on the Vita shade guide. Full crowns made from this material could then be used with confidence, including with regard to aesthetic parameters. A material has therefore been found that builds on the clinical experience of gold.

#### Reference

1. Siewert B, Parra M: Eine neue Werkstoffklasse in der Zahn, edizin. PEEK als Gerüstmaterial bei 12-gliedrigen implantatgetragenen Brücken (A new material class in dentistry. PEEK as a framework material with 12-unit, implantsupported bridges). Z Zahnärztl Implantol 2013;29:148-159.





