PEEK IMPLANT-SUPPORTED FULL-ARCH BRIDGEWORK

Written by **Professor Paul Tipton**

Professor Paul Tipton examines the application of the high-performance polymer PEEK for CAD/CAM produced full-arch implant-retained prostheses

Polyether ether ketone (PEEK) high-performance 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.

Today, it is widely believed that high-performance polymers have a great future potential with regard to their use as framework materials in restorative dentistry. While for a long time, they have been exclusively used for temporary restorations, new application options are created due to the availability of innovative, optimised materials such as polyether ether ketone (PEEK). This material for example can be used successfully for the computer-aided production of long-span, implant-supported restorations.

FRAMEWORK MANUFACTURE

There are two methods for laboratories to manufacture substructure frameworks from PAEKs. These are: (i) injection moulding or (ii) CAD/CAM.

(i) Industrial injection moulding machines process the polymer under very high speed and pressure (eg 1000's bar), which are typically two orders of magnitude higher than the typical bench-top pressing machines available to the dental laboratory (eg 10's bar). This means that small-scale injection moulding of PAEK is no mean feat, due to tight processing windows and design limitations. Also these re-melting of PAEKs can also increase the risk of unpredictable mechanical and physical properties (eg brittleness, flexibility, colour, warping) if the framework has not cooled and recrystallised correctly.

Finally, re-melting of PAEK materials can also cause degradation of the polymer (eg generation of phenol) unless very closely controlled using the correct equipment. This polymer degradation can be accentuated by the inclusion of fillers in the materials (such as reinforcing agents or pigments). Therefore, melt processing of these materials should only be done by a competent laboratory and using appropriate equipment.

(ii) The alternative manufacture route uses CAD/CAM technology. This manufacturing route minimises the risks mentioned previously for re-melting the polymer. The material properties remain consistent and the framework manufacture can also benefit from the increased precision and reproducibility of a digital workflow. Although it does require a more significant capital investment by the laboratory, many laboratories are seeing that it is necessary to align with other industries and adopt digitisation to increase efficiencies.

PAEK materials further extend these CAD/CAM efficiencies when compared to milling metal substructures, since there is typically less tool wear and faster milling times and the capital equipment necessary to mill them does not need to be as expensive as machines for milling metal frameworks.

It is the author's view that the optimum use of these materials only comes from the CAD/CAM milling process as opposed to the injection moulding process.

The advantages of CAD/CAM are as follows:

- 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 enables the shape contoured during software-supported fabrication to be retained.

SHOCK ABSORBING EFFECTS

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 shock-absorbing effect to prevent overloading of the patient's natural teeth and the implants.

PEEK with its modulus of elasticity of approximately 4GPa has the advantage therefore of limiting the transfer of masticatory bones to the bone and peri-implant tissues. Overloading, often encountered with rigid materials such as titanium (modulus of elasticity: 110 GPa) or zirconia (modulus of elasticity: 210 GPa), ▶

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Figure 1: Upper and lower temporary acrylic bridges in place.

Figure 2: Lower stone verification jig repaired with Duralay

Figure 3: Upper stone verification jig fitting passively

Figure 4: Lower PEEK framework

Figure 5: Upper PEEK framework

Figure 6: PEEK frameworks on the semi adjustable articulator

Figure 7: PEEK frameworks tried in the mouth for passive fits

Figure 8: Try in of PEEK frameworks, acrylic teeth and wax

Figure 9: Lower Acrylic/PEEK bridge (front view)

Figure 10: Upper Acrylic/PEEK bridge (fitting surface view)

Figure 11: Upper Acrylic/PEEK bridge (anterior view)

Figure 12: Upper Acrylic/PEEK bridge (occlusal view)

can thus be avoided.

The weight of the restoration as a whole may be frequently an underestimated issue. In the edentulous jaw, implants are often placed beyond the area of the tooth roots (in basal bone). As a result, the prosthetic restorations sometimes exhibit an exceptionally high vertical dimension, resulting in massive frameworks. The low specific mass of PEEK is promising in this respect. The excellent physical and chemical properties of PEEK and its excellent biological compatibility are also promising when it comes to its use in implant prosthodontics, PEEK has very low absorption and therefore remains odourless even after prolonged wear.

The following case studies show the clinical stages involved in the making of PEEK framework full and implant supported bridgework.

CASE STUDY 1

The patient, aged 71, presented with existing upper and lower dentures requesting fixed bridgework and implants. Her initial medical history indicated controlled diabetes but not other problems. Initial treatment was All-on-6 in the upper and All-on-4 in the lower (Figure 1).

After a period of six months, the restoration of the upper and lower implants with a full-arch PEEK bridge was started. After initial pick-up impressions a stone verification jig was used to assess the accuracy of the impressions in both upper and lower jaws (Figures 2-3). You will see that the lower stone fractured during ▶

Figure 13: Acrylic/PEEK bridges fitted in the mouth (retracted view)

Figure 14: Final smile

tightening of the screws indicating a misfit. It was 'duralayed' together in the mouth and the distal implant analogue relocated, prior to proceeding to framework fabrication. The verification jigs are used to assess the accuracy of the vertical pick-up impressions.

PEEK frameworks were then fabricated by the laboratory (Figures 4-6) and tried in the mouth and then assessed for fit in the mouth (Fig 7).

After verification of the fit of the frameworks, try in stage was performed to evaluate aesthetics, phonetics and occlusion. (Figure 8).

The frameworks were then processed and covered with acrylic (Figures 9-12). The final framework were then fitted (Figures 13-14).

CASE STUDY 2

The patient, aged 55, presented with a poor dentition, lack of posterior stability and was overclosed, leading to an aged look for her age (Figure 15). She was medically fit and well.

The initial treatment involved removal of all remaining teeth, flattening of the edentulous ridges, placement of four upper and four lower implants and immediate loading in both jaws. (Figure 16).

The definitive acrylic/PEEK bridge fabrication started with removal of the temporary immediate all acrylic bridges and impressions of the multi unit abutments using the pickup impression technique (Figures 17-18).

Stone verification jigs were produced by the technician and used to verify the accuracy of the initial impressions (Figures 19-20). Both jigs fitted passively with no fractures indicating accuracy of the initial impressions.

PEEK frameworks were then fabricated by the technician (Figures 21-22) These frameworks were then tried in the mouth to assess passivity of fit (Figures 23-24).

The patient requested a much younger appearance and so whiter brighter teeth were used in the fabrication of the final bridges (Figures 25-26). The final restorations can be seen in the mouth (Figures 27-28).

CASE STUDY 2

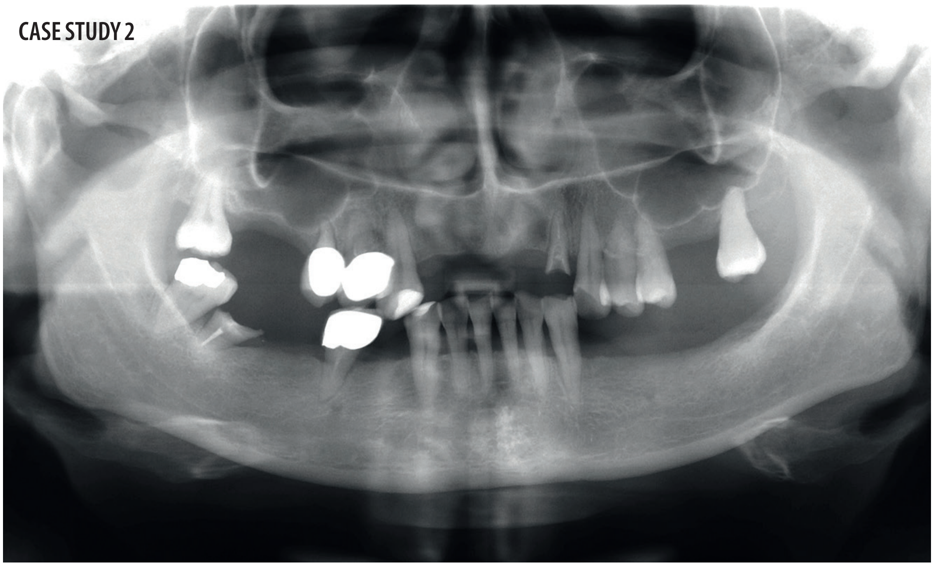

Figure 15: Initial OPG radiograph.

Figure 16: After initial loading at six months review

Figure 17: Lower multi-unit abutments in situ

Figure 18: Upper mult-unit abutments in situ

CONCLUSION

PEEK offers the dentist a metal-free restorative treatment option that is particularly well suited for complex implant-supported restorations in edentulous or nearly edentulous jaws. Ideally, the PEEK frameworks are fabricated using CAD/CAM. CAD/CAM blanks are industrially prefabricated under standardised conditions (temperature, pressure), generally of uniformly high quality. Due to the material properties, masticatory forces are transferred to the bone or peri-implant tissue in attenuated form, protecting the bony structures around the implant and thus offering a shock absorbing effect which may also help in bruxism patients. These two patients were fit and well at the end of treatment with excellent and much improved oral health. Clinical feedback was excellent both in terms of general feel and look of the prostheses. The restoration is also very light and comfortable to wear and both patients remarked on the lightness.

Ultimately, the excellent chemical properties of PEEK and its excellent biocompatibility make it a highly promising material for use in implant prosthodontics. ●

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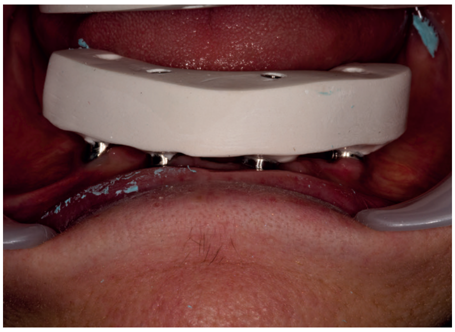

Figure 19: Lower stone verification jig

Figure 20: Upper stone verification jig

Figure 21: Upper PEEK framework

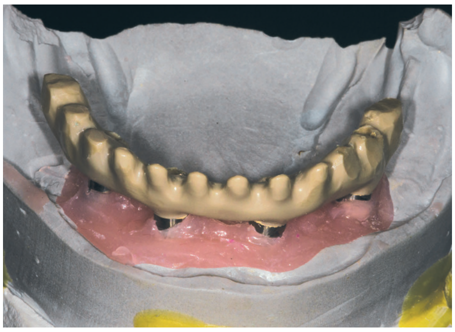

Figure 22: Lower PEEK framework

Figure 23: Upper PEEK framework in mouth

Figure 24: Lower PEEK framework in mouth

Figure 25: Upper Acrylic/PEEK framework (anterior view)

Figure 26: Upper Acrylic/PEEK framework (fitting surface view)

Figure 27: Acrylic/PEEK bridges in the mouth

Figure 28: Final Smile