A PROSTHODONTIST'S EXPERIENCE WITH JUVORA™ IMPLANT BRIDGES

BY PROFESSOR PAUL TIPTON

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BIOMATERIAL SOLUTIONS

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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.

Professor Paul Tipton Biography

A highly respected Specialist in Prosthodontics, Paul has published over 100 scientific articles in the dental press and is an expert lecturer in his field with Tipton Training Academies in Manchester, London and Dubai (www.tiptontraining.co.uk). After gaining his Masters Degree in Conservative Dentistry in 1989, he was awarded the Diploma in General Dental Practice by the Royal College of Surgeons four years later and received Specialist status in Prosthodontics in 1999 from the GDC. He is currently Professor of Cosmetic Dentistry at the City of London Dental School and BPP University, and President of the British Academy of Restorative Dentistry (www.bard.uk.com). An ex-professional cricketer with Lancashire County Cricket Club. He is one of the UK's most successful dentists in the UK (www.drpaultipton.com) with specialist clinics in Manchester and London (www.tclinic.co.uk) and regularly appears in the Dentistry Top 50 UK dentist's poll.

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 increase 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.

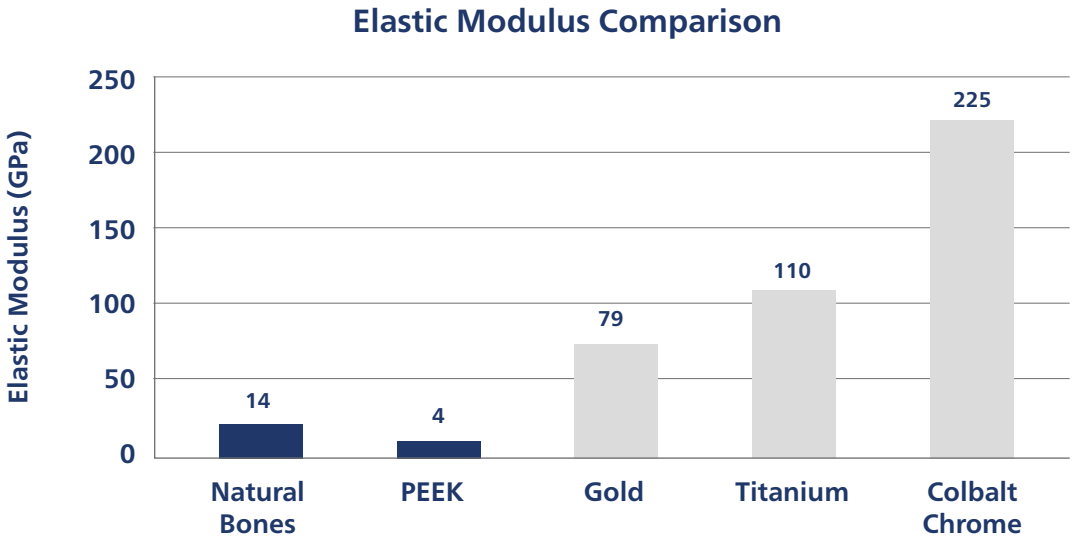
PAEK materials further extend these CAD/CAM efficiencies when compared to milling metal substructures, since there is typically less tool wear and faster milling times and the capital equipment necessary to mill them does not need to be as expensive as machines for milling metal frameworks.

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.

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



Rho, JY (1993). " Young's modulus of trabecular and cortial bone material". Journal of Biomechanics 26 (2): 111-119

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), 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.

Fabrication of Prosthesis

The steps in the fabrication of the PEEK implant prosthesis are as follows:

Step 1 – Impression

Pick up impressions are advised rather than the transfer types for added accuracy. Transferring these impression copings back into the impression from the mouth with analogues attached gives a less accurate result. Splinting the copings together with floss and acrylic, composite or hard bite registration paste is also advised prior to the impression to minimise movement of the copings when the impression is removed.

Caution however in that these materials shrink and so once splinted and the material has set the newly created framework should be sectioned and again reattached but with minimal material to minimise further contraction. Ideally a rigid impression material such as polyether or even impression plaster should be used, as the pick up impression material.

Step 2 – Verification Jig

The accuracy of the master model should be verified with a verification jig made from plaster and not acrylic. Plaster will fracture rather than deform (acrylic will bend and deform) so a rigid material which is weak and easily fractured is the ideal choice. Should the plaster fracture then this indicates the master model is inaccurate and the plaster verification Jig is 'bonded' together and sent back to the lab. The analogues are reposited in the master model and the process continues, now with an accurate master model.

Step 3 – Bite Registration

This can be done ideally using a Gothic Arch Tracing or via the bimanual manipulation technique in order to get the condyles into Retruded Contract Position (RAP). This after all is a full mouth reconstruction and so it is essential for the long term comfort of the patients muscles and joints and the longevity of the restoration that muscles, joints and replacement teeth are all working in harmony. If this is not the case, then there is the problem of significant interferences being introduced between the RAP and any new ICP produced. If the patient, then parafunctions this puts extra stress not only on the implant superstructure but also the implants. Again here PEEK with its stress absorbing abilities can be a significant advantage.

Step 4 – Try in Framework

The try in stage is in order to assess the fit of the newly milled PEEK framework prior to the addition of the acrylic teeth on top. At this stage a further jaw registration can be completed using the bimanual technique again as a verification but this time a jaw registration verification. These bridges should be made on a semi-adjustable articulator or preferably a fully adjustable articulator set via lateral and protrusive check bites, Cadiax or Pantograph.

Step 5 – "Try in" Acrylic Teeth/PEEK

At this stage the new teeth set in wax on the PEEK framework are tried in and adjusted as required. Adjustment can be via grinding or better at this stage for the wax knife to come out and with heated wax the teeth can be moved to produce not only an excellent and accurate occlusal scheme but some amount of characterisation if required.

Step 6 – Fit

Ideally the traditional way of screwing down the prosthesis is followed criss-crossing and tightening from one side to the other. Final occlusal adjustments are made so that there is shimstock holding contacts on all posterior teeth with slightly lighter contacts on the anterior segment. No contacts on any cantilevers and shallow anterior guidance should be encouraged. Shallow cusp angles on the posterior teeth allow for shallow anterior guidance so essential for the health of the masticatory system. Group function in right and left lateral guidance should be introduced with the guidance being as close to the implant abutments as possible.

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 (Fig. 1).

Fig. 1 – Upper and lower temporary acrylic bridges in place.

After a period of 6 months the restoration of the upper and lower implants with 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 (Figs 2, 3). You will see that the lower stone fractured during tightening of the screws indicating a mis fit. 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.

Fig 2 – Lower stone verification jig repaired with Duralay

Fig 3 – Upper stone verification jig fitting passively

PEEK frameworks were then fabricated by the laboratory (Figs 4, 5, 6) and tried in the mouth and

Fig. 4 – Lower PEEK framework

Fig. 5 – Upper PEEK framework

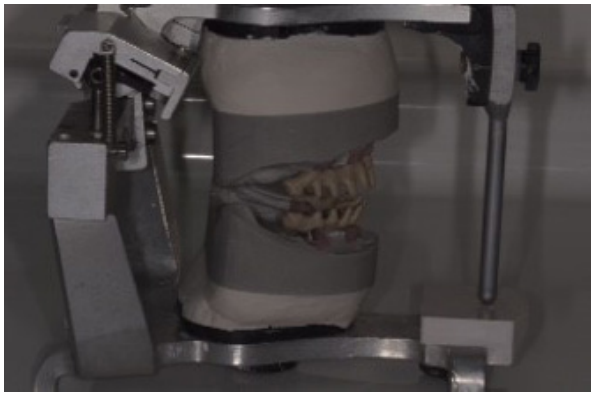


Fig. 6 – PEEK frameworks on the semi adjustable articulator

then assessed for fit in the mouth (Fig 7).

Fig. 7 – PEEK frameworks tried in the mouth for passive fits

After verification of the fit of the frameworks, try in stage was performed to evaluate aesthetics, phonetics and occlusion. (Fig. 9).

Fig. 9 – Try in of PEEK frameworks, acrylic teeth and wax

The frameworks were then processed and covered with acrylic (Figs 10-13).

Fig. 10 – Lower Acrylic/PEEK bridge (front view)

Fig. 11 – Upper Acrylic/PEEK bridge (fitting surface view)

Fig. 12 – Upper Acrylic/PEEK bridge (anterior view)

Fig. 13 – Upper Acrylic/PEEK bridge (occlusal view)

The final framework were then fitted (Figs 14, 15).

Fig. 14 – Acrylic/PEEK bridges fitted in the mouth (retracted VIEW)

Fig. 15 – Final smile.

The frameworks were then processed and covered with acrylic (Figs 10-13).

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 (Fig. 16). She was medically fit and well.

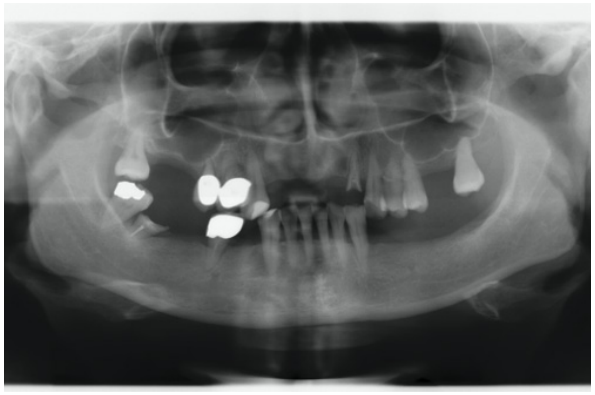


Fig 16. – Initial OPG radiograph.

Fig. 17 – After initial loading at 6 months review

The initial treatment involved removal of all remaining teeth, flattening of the edentulous ridges, placement of 4 upper and 4 lower implants and immediate loading in both jaws. (Fig. 17).

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 (Figs 18, 19).

Fig. 18 – Lower multi-unit abutments in situ

Fig. 19 – Upper mult- unit abutments in situ

Stone verification jigs were produced by the technician and used to verify the accuracy of the initial impressions (Figs 20, 21). Both jigs fitted passively with no fractures indicating accuracy of the initial impressions.

Fig. 20 – Lower stone verification jig

Fig. 21 – Upper stone verification jig

PEEK frameworks were then fabricated by the technician (Figs 22,23)

Fig. 22 – Upper PEEK framework

Fig. 23 – Lower PEEK framework

These frameworks were then tried in the mouth to assess passivity of fit (Figs 24, 25).

Fig. 24 – Upper PEEK framework in mouth

Fig. 25 – Lower PEEK framework in mouth

The patient requested a much younger appearance and so whiter brighter teeth were used in the fabrication of the final bridges (Figs 26, 27).

Fig. 26 – Upper Acrylic/PEEK framework (anterior view)

Fig. 27 – Upper Acrylic/PEEK framework (fitting surface view)

The final restorations can be seen in the mouth (Figs 28,29).

Fig. 28 – Acrylic/PEEK bridges in the mouth

Fig. 29 – Final Smile

6 and 12 month follow-up: my perspective

Review of the prosthetics at 6 months and 1 year showed the same status and overall appearance as per when it was fitted, with treatment objectives achieved.

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 standardized conditions (temperature, pressure), generally of uniformly high quality (9,11).

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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