Five-year clinical retrospective study

Survival and treatment success of full-arch implant-supported PEEK prostheses

DR BERND SIEWERT, POZUELO DE ALARCÓN, SPAIN

Over the last two decades, edentulous patients have increasingly been treated with screw-retained full-arch implant-supported prostheses [1,2]. Traditionally, these prostheses have been fabricated with rigid metal frameworks or, more recently, rigid zirconia frameworks [3]. The present study aimed to evaluate the survival rate of implant-supported full-arch prostheses with polyether ether ketone (PEEK) frameworks, to specify the kind of problems that occurred in the observation time, to assess survival rates, to investigate the behaviour of peri-implant bone and to quantify the oral health-related quality of life (OHRQoL) and patient satisfaction.

Rigid materials do not prevent the implant and other parts of the design, such as screws and other fragile parts, from local occlusal overload and may cause damage or fracture [4] and thereby impair the quality of life of bruxism patients. The established treatment solutions – (a) metal-ceramics; (b) all-zirconia; (c) metal-reinforced acrylic implant-supported bridges – still exhibit clinical problems [5]. Certain materials can act as occlusal shock absorbers [6]. The question was whether a high-performance polymer such as polyether ether ketone (PEEK) might be an improved alternative to the established solutions. Additionally, given increasing patient and clinician demand for metal-free restorations supported by zirconia implants, polyether ether ketone (PEEK) is an alternative to metal in these cases.

Implantable PEEK polymer (Peek-Optima; Invibio, Thornton Cleveleys, UK) has been used clinically for 15 years. With more than five million cases, implanted PEEK devices have become an industry standard across a wide range of medical applications, including spinal fusion, due to their excellent mechanical properties, strength-to-weight ratios and chemical stability [7].

PEEK has had some use in dentistry over the last decade, mainly in the form of temporary abutments and healing caps, but the material has remained somewhat underutilized [8]. This material is extremely interesting for use as frameworks for full-arch, implant-supported prostheses due to its proven biocompatibility and resilience [9]. The present study investigated the clinical outcome of using PEEK polymer as a framework material in full-arch, implant-supported prostheses.

Materials and methods

Ethics

This report is a retrospective review of one clinician's private practice of which the clinician was the Clinical Director. Consent was obtained from all patients included in the study.

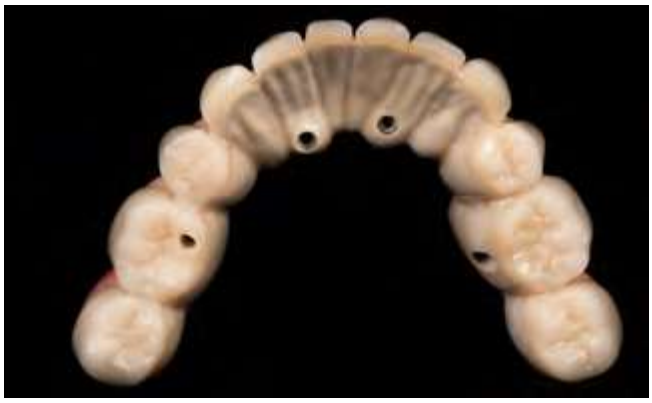
Patient selection

A retrospective data review of dental records at the private clinic was conducted for patients treated between March 2008 and October 2016. The patient included were single-arch edentulous patients treated with PEEK implant-supported full-arch prostheses over 18 years who were willing to return for follow-up assessments. 2 patients who met these criteria could not be included as they had died of causes unrelated to their dental treatment. 20 patients were deemed eligible to be included in the analysis.

Implants and prostheses

All patients were treated with full-arch implant-supported screw-retained (horizontal (Fig. 1) or occlusally retained (Fig. 2) bridges with PEEK frameworks. The PEEK surface was sandblasted with 80 µm aluminium oxide at a pressure of 2,5 bar and treated with a Primer (VisioLink; Bredent, Senden, Germany). The framework was then veneered with prefabricated multilayer PMMA composite veneers (novo.lign; Bredent) using a

1 I Laboratory intaglio view of a PEEK framework with one of the four horizontal screw titanium abutments in place.



2 I Laboratory occlusal view of a veneered PEEK framework with four occlusal screws.

special PEEK Primer (visio.link; Bredent) and a dual-curing resin (combo.lign; Bredent).

In total, 92 titanium implants were placed, 80 in the maxilla and 12 in the mandible. The implants used were: 10 × BEGO Semados RS implants (BEGO, Bremen, Germany); 56 × blueSKY implants (bredent medical; Senden, Germany); 12 × MPI Excellence implants ASTRA TECH type internal connection (Medical Precision Implants, Madrid, Spain); 4 × MPI Excellence implants with a Brånemark-type external connection (Medical Precision Implants); 10 × PITT-EASY implants (Sybron Dental Specialities, Bremen, Germany). The surgical procedures used to place the implants and deliver the prostheses were performed by *Dr Siewert* in accordance with the manufacturer's recommendations. 14 patients received 67 implants placed following a delayed approach with an observed minimum healing period of four months prior to loading with the definitive PEEK prostheses. The remaining 25 implants of 6 patients were immediately loaded with ten-unit provisional PMMA screw-retained prostheses with glued-in titanium abutments. The definitive PEEK bridge was delivered after a minimum of five months.

None of the dentures faced a complete denture in the antagonist jaw. One patient wore an implant/bar-retained overdenture, two patients had natural teeth with a removable clasp-retained denture in the molar region, two patients had a cemented metal-ceramic restoration from canine to canine with a removable part attached in the molar region, one patient wore a full-arch metal-ceramic restoration, two patients had their natural dentition and the remaining twelve patients wore single or crown or short ceramic bridges restorations on natural teeth or implants. Figures 3 to 7 demonstrate a representative case over the observation period.

Patient evaluation

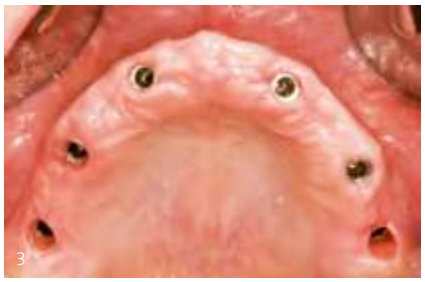
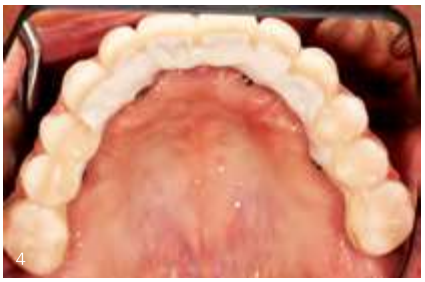
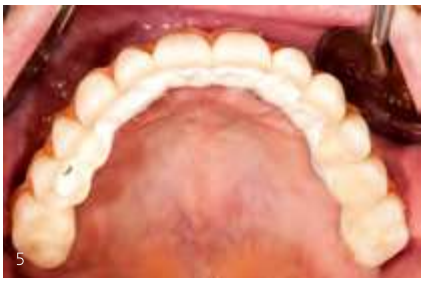
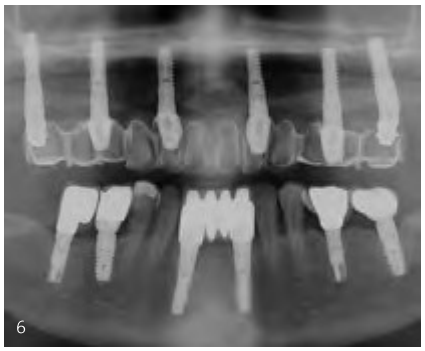
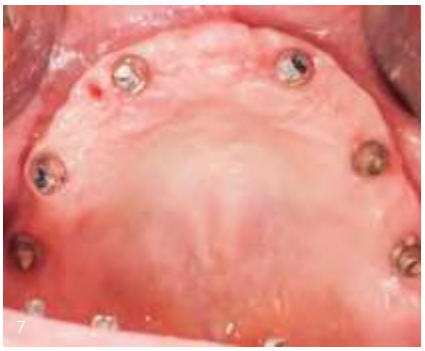
All patients had been followed up by *Dr Siewert* after prosthetic delivery. All patients were asked to return to the clinic for a further assessment between October and December 2016. 18 of the 20 patients returned for this assessment. For the 2 subjects who did not return, the data from their previous follow-up assessment was used in the analysis. 8 patients had to be treated for failure of metal-ceramic restorations on natural teeth or implants due to fractures of the ceramic, the metal framework, natural roots, or fracture or loss of implants. These patients were considered a special risk group due to their bruxism.

Clinical and radiological assessments

For bone-loss assessment, each patient had extraoral radiographic examinations using an Instrumentarium OP100 D Panoramic X Ray orthopantomograph (KaVo Dental) to measure their marginal bone loss. The panoramic radiographs taken on the day the restorations were delivered was considered as the baseline radiograph of each patient. A panoramic x-ray was taken of each patient included in the study at the end of the observation period. As the study is a clinical retrospective one, the radiographs were only standardized to the extent that they were done using the same machine operated by the same person and following a strict positioning protocol. Digital data was then analyzed with the dental imaging software Cliniview (Kavo Dental, Biberach, Germany) using the following protocol: Each image was optimized by adjusting brightness, contrast and gamma. Each image was then calibrated prior to the length measurements of the mesial and distal aspect (Figs. 8a and 8b). To improve measurement accuracy, the region to be measured was adequately amplified. The distance between the implant shoulder line and the crestal bone line was measured in the distal and mesial sides of the implant.

At the recall appointments, the clinical examination also assessed the peri-implant tissue health, measuring pocket depths and bleeding on probing. Each patient had a clinical examination to screen for peri-implantitis with the implants being evaluated as follows: cumulative bone loss > 2 mm, depth probing depths > 4 mm with simultaneous bleeding and/or suppuration, implant mobility, and crater-like bone defects [10–15].

Survival of the implant and prostheses was also evaluated, where failure was defined as "an implant/prosthesis that had to be removed for any reason". Information regarding any adverse events, including conditions at onset and

3 I Initial situation prior to prosthesis delivery, occlusal view (June 2008).
4 I Full-arch screw-retained prosthesis with PEEK framework in place, occlusal view (June 2008).
5 I The same prothesis at the recall appointment eight years later (October 2016).
6 I Panoramic radiograph at the recall appointment eight years after insertion (October 2016).
7 I Situation with prothesis removed at the recall appointment eight years after insertion (October 2016).

any measures taken was noted. Adverse events did not always result in removal of the restoration. Each patient was also examined with respect to the appearance of the restorations and any abutment- and attachment-related component complications.

At the end of the observation period (end of 2016), patients were asked to complete the Oral Health Impact Profile survey in a validated Spanish version (OHIP-14Sp) [16], scored using an adaptation of the Likert scale (0 = least impact/never, 4 = highest impact/always). Separately, all 20 patients were asked to rate their satisfaction on a scale from 1 to 10 (1 = least satisfaction/extremely dissatisfied, 10 = greatest satisfaction/extremely satisfied).

Results

Patient details

The average follow-up post-implantation was 77 months, with a range of 18 to 105 months. The average follow-up post-prosthetic placement was 56 months (4 years and 8 months), with a range of 14 to 105 months (8 years and 9 months).

Primary outcomes: implant and prosthetic survival

The implant survival rate was high (99 %), with 1 implant out of 92 failing after 7 years in service, observed in a patient with a clinical history of severe periodontitis and the extraction of all remaining teeth prior to implantation as well as cancer treatment.

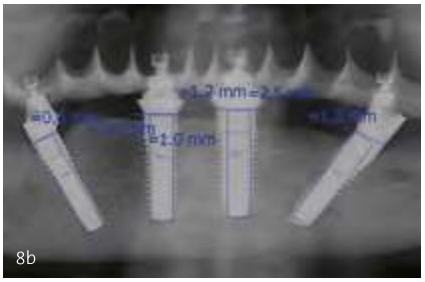
The survival rate of the PEEK prostheses was high at (100 %), with none of the 20 prostheses failing over the average review period of 56 (14–105) months.

Clinical and Radiological Assessments

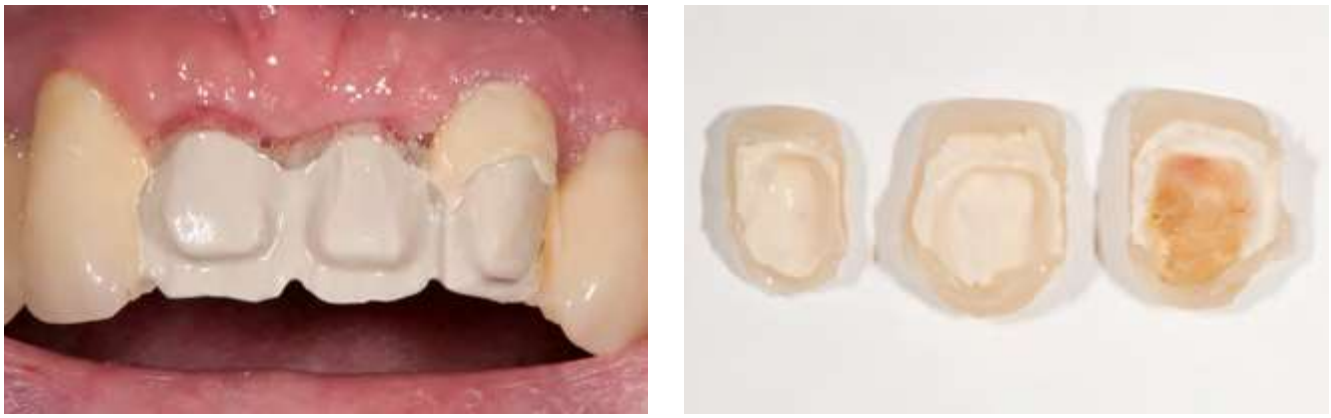
Bone loss was evaluated at a number of time points following the placement of the PEEK prostheses. Bone loss after an average of 54 months (4 years and 6 months) was 0.2 ± 1.0 mm on the mesial aspect and 0.3 ± 0.8 mm on the distal aspect.

The peri-implantitis incidence was low (1 %). Peri-implantitis was observed around one implant, with the remaining 91 implants showing no indication of peri-implantitis during the follow-up period.

No prosthetic complications such as abutment corrosion, abutment decementation or screw loosening were observed. Veneer chipping occurred in five cases and could be divided into two groups. The first group included 2 cases of early chipping within the first month after bridge placement, due to a mistake in the bonding process (Figs. 9a and 9b). Following repair in the dental laboratory, no more instances of this kind of chipping were observed. The second group included are 3 cases of so-called late chipping, single-veneer fractures after

8 I Representative example case for the measurement protocol of the mesial and distal peri-implant bone levels in detail of the panoramic radiography I a: Initial reference when the definitive restoration was installed after calibration process (September 2013) I b: Final reference at the end of the observation period after calibration process (November 2016).

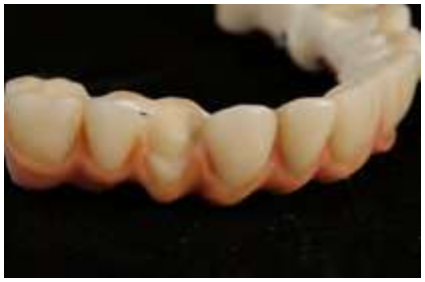


9a & b I Examples of early veneer chipping (within the first month of placement), due to bonding process in the laboratory.

several years of use, due to changes in the occlusal pattern (Fig. 10); it only occurred in the subgroup of bruxers, and all 3 cases could be repaired at chairside in the dental office.

18 patients completed the OHIP-14 questionnaire between October and December 2016.

The maximum possible score for the OHIP-14 is 56 points, representing the worst possible OHRQoL result, and the minimum score is 0 points, representing the best possible OHRQoL result. The mean total OHIP-14 score was 3.1 ± 3.3 points after an average follow-up of 58 months (4 years and 10 months) with a range of 0 to 12 points. In addition, 27.8 % of patients exhibited a score of 0 and 66.7 % of patients one of 3 or less. Apart from the OHIP-14 questionnaire, all 20 patients in the study were interviewed and asked to score patient satisfaction on the 1–10 scale. Patients rated patient satisfaction high, with a mean score of 9.3 ± 0.9.



10 I Examples of late veneer chipping, six years after placement, caused by occlusal abrasion of the PMMA veneers.

Bruxism patients

A subset of 8 patients with bruxism (defined as patients who grind, gnash or clench their teeth) was also identified with an average prosthetic treatment time of 51 months. All patients completed the OHIP-14 questionnaire; the mean total OHIP-14 score for this group was also low at 3.9 ± 3.4. The 8 bruxism patients rated their satisfaction at 9.4 on the 1–10 scale. The bruxism patients demonstrated implant and prostheses survival rates of 100 %, a low rate of bone loss (0.1 ± 0.8 mm on the mesial aspect and 0.3 ± 0.8 on the distal aspect), and no incidence of peri-implantitis.

Discussion

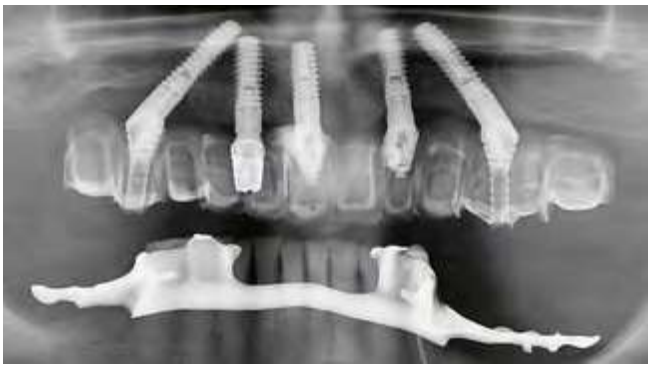
Several studies have reviewed implant and prostheses survival rates of metal implant-supported fixed complete full-arch dental prostheses (IFCDPs). The reported implant survival at 5 years is high, at 94.3 % [17], and the correspondent full-arch prostheses survival rate is also high, at 91.4 % [18,19]. For the 20 patients followed in this study, the implant survival rate was 99 % and the prostheses survival rate was 100 %. This improved survival of the implants and the associated prostheses might be due to the increased flexibility of the PEEK material (lower elastic modulus than titanium [20]), resulting in improved shock absorption by the prostheses [21,22]. The improved shock absorption may shield some of the chewing forces, improving patient comfort and potentially helping to preserve the bone around the implants.

The rate of bone loss around implants has been reported as around 0.19 mm per year [23]. After a five-year period, it has been reported average marginal bone loss could reach approximately 1.5 mm [24]. In the present study, much less bone loss was observed (0.2 ± 1.0 mm on the mesial aspect and 0.3 ± 0.8 mm on the distal aspect), which could be related to the shock absorption benefits conveyed by the PEEK prostheses, shielding heavy loads and potentially preserving the bone. Additionally, it should be considered that the modulus of elasticity of the veneered PEEK framework bridges is more likely to guarantee a 100 % passive fit than rigid structures, because minor intolerances are compensated.

Peri-implantitis is an infectious condition of the tissues around osseointegrated implants with loss of supporting bone and clinical signs of inflammation. The prevalence of peri-implantitis has been stated to be present in about 10 per cent of implants [17,25]. The low incidence of peri-implantitis observed in this study (1.1 %) could be related to the good bone preservation around the implants, which again might be derived from the improved shock absorption behaviour of the PEEK material. Another element that could contribute to the low incidence of periimplantitis is the metal-free nature of PEEK prostheses.

Concerns about corrosion and the release of metal ions resulting from galvanic coupling of the metallic prostheses with the metallic implant system have been raised [26,27], and in the present

11a I Panoramic radiography of a patient with bruxism at four months follow-up after prosthesis placement.



11b I Panoramic radiography of the same patient at 70 after prosthesis placement.

situation this is mitigated by the usage of a metal-free prosthesis. The natural inertness and biocompatibility of the PEEK material [7], combined with the flexibility of the material allowing a more forgiving passive fit, could also help maintain a long-term healthy tissue.

One case of peri-implantitis was observed in a patient with an early diagnosis of severe periodontitis. Although just one implant out of a total of four implants in the mandible of this patient was affected it has been suggested that patients with a diagnosis of periodontitis could be at greater risk of developing peri-implantitis [28–30].

The patient's OHRQoL is an outcome believed to be highly favourably affected after improving the shock absorption behaviour of the implant/prosthetic system [31]. The OHIP-14 questionnaires of 18 patients reported very low average results, with 94 % of patients reporting never or hardly ever having had a problem with pain, and 89 % of patients reporting never or hardly ever having had a problem with sensitivity or discomfort due to dentition-related issues. The OHIP-14 observations were in line with patient satisfaction reported by all 20 patients, who were extremely satisfied at a level of 9.3 on the 1–10 scale. Similar OHIP-14 studies conducted with implant-supported full-arch prostheses have reported around 75 % of patients scoring at the never/hardly never/extremely satisfied level [32]. As with the clinical outcomes, patient satisfaction and comfort seemed to be improved by the use of the PEEK prostheses.

The impact that PEEK as a prosthetic material might have in reducing the patients' pain and discomfort becomes even more relevant for patients affected by parafunction (bruxism and pressing). Tooth pressing, also called centric bruxism, which could affect as much as 20 % of patients, has been suggested to cause excessive occlusal load on implants and prostheses, resulting in excessive bone loss around the implants, implant failure and even damaged prostheses [33,34].

Of the 20 patients followed, a subset of eight patients affected by parafunctions was identified. Parafunction patients' OHIP-14 scores remained low at 3.9, with these patients ranking satisfaction high at 9.4 on the 1–10 scale. The parafunction patients with an average prostheses treatment time of 51 months demonstrated 100 % implant and prosthetic survival rates, a low rate of bone loss (Figs. 11a and b) and no incidence of peri-implantitis. The follow-up examinations showed that the antagonist situation remained stable over the years, with no further tooth loss, no periodontitis and no bone loss.

No differences were observed in terms of the quality of life and clinical outcome assessed between the subset of parafunction patients and other patients. This seems to indicate that the benefits derived from a prosthesis with greater shock-absorbing capacity can be felt even by patients with parafunctions, substantially improving their quality of life in comparison with the more rigid metal-based prostheses.

Conclusion

Within the limitations of this study, patients treated with PEEK full-arch implant-supported prostheses showed high implant and prostheses survival rates with low peri-implant bone loss and a low incidence of peri-implantitis. OHRQoL scores and patient satisfaction were found to be extremely satisfactory, even in bruxism patients. Veneer chipping presented the only prosthetic complication, indicating that the veneers must be connected accurately and precisely. On the other hand, the incidence of chipping in bruxers was lower than reported in the literature. One advantage is that the material permits easy repairs even at chairside.

It is suggested that the observed improvements in OHRQoL and clinical outcomes could be related to the enhancement in shock absorption provided by the PEEK prostheses, which might help preserve the bone around the implants and reduce patient pain and discomfort even in the case of patients affected by bruxism. A prospective study with a larger number of patients would be beneficial. ■

The references are available at www.teamwork-media.de/literatur

Contact address

Dr Bernd Siewert
Calle Aquilón, 2
Local 7/8
28223 Pozuelo de Alarcón
Spain
siewert@dental-med.com