

Survival rates and treatment success with full-arch implant supported polyetheretherketone (PEEK) prostheses: A 5 year clinical retrospective study

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## **ABSTRACT**

**Purpose.** This study aimed to evaluate the survival rate of implant supported full-arch prostheses with PEEK frameworks, specify the kind of problems that occurred in the observation time, assess survival rates, measure the behavior of periimplant bone and quantify quality of life and satisfaction of these patients.

**Materials and Methods.** 20 PEEK implant supported full-arch prostheses were placed in 20 patients (17 maxillary and 3 mandibular), corresponding to a total of 92 implants, meaning an average of 4,6 implants per patient.

**Results.** Dental implant survival rate was 99%, and PEEK prostheses survival rate was 100%. Bone loss after an average of 54 months (4 years and 6 months) was 0.2mm ( $\pm$  1.0) on the mesial aspect and 0.3mm ( $\pm$  0.8) on the distal aspect. Patient peri-implantitis incidence was 1%. At the end of the observation period all patients were asked to respond to the questions of the OHIP-14 questionnaire. The mean total OHIP-14 score was 3.1 points ( $\pm$  3.3) with patient satisfaction

deemed 'extremely satisfactory'. Similar results were shown in a sub-set of 9 patients with bruxism.

**Conclusions.** Based on the results of this study, it is suggested that the observed improvements in quality of life and clinical parameters could be related to the enhancement in shock absorption and the elasticity provided by the PEEK prostheses (frameworks), which might help preserve the bone surrounding the dental implants and reduce patient pain and discomfort even in the case of complex situations, such as patients affected by bruxism.

**KEYWORDS:** polymer; fixed partial denture; framework; peri-implantitis; bone level; OHIP

## **INTRODUCTION**

Over the last two decades, edentulous patients have increasingly been treated with a screw-retained full-arch implant supported prostheses<sup>1,2</sup>. Traditionally, these prostheses have been fabricated with rigid metal frameworks and, more recently, rigid zirconia frameworks<sup>3</sup>.

Rigid materials do not prevent the implant and other parts of the construction, as for example screws and other fragile parts, from punctual occlusal overload and may cause damage or fracture<sup>4</sup> and in this manner impact patient quality of life in bruxism patients. The established treatment solutions ( a: Ceramic fused to metal b: full zirconia c: metal reinforced acrylic im-

plant supported bridges) clinically manifest still problems <sup>5</sup>. Certain materials have the ability to act as an occlusal shock absorber <sup>6</sup>. The question was if a high performance polymer such as the Polyetheretherketone (PEEK) could be an improved alternative to the established solutions. Additionally, with the increasing patient and clinician demand for metal free restorations supported on zirconia implants, Polyetheretherketone (PEEK) is a metal alternative for such cases.

Implantable PEEK polymer (Peek-Optima; Invibio Ltd.) has been used clinically for 15 years. In over five million cases, implanted devices across a wide range of medical applications, including spinal fusion, have become an industry standard implant material due to excellent mechanical behavior, strength to weight ratio and chemical stability <sup>7</sup>.

PEEK has had some use in dentistry over the last decade mainly as temporary abutments and healing caps, but the material has remained somewhat under-utilized <sup>8</sup>. This material is extremely interesting for use as frameworks for full arch, implant supported prostheses due to its proven biocompatibility and resilience <sup>9</sup>. This study investigated the clinical outcome of using PEEK polymer as a framework material in full arch, implant retained 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 inclusion criteria were: single arch edentulous patients treated with a PEEK implant supported full-arch prostheses, over 18 years of age and willing to return for follow-up assessments. 2 patients who met the

inclusion criteria could not be included as they had died 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 (horizontal (Fig 1) or occlusal (Fig 2)) retained bridges with a PEEK framework. The PEEK surface was sandblasted with 80um aluminium oxide with a pressure of 2,5 bar and treated with a Primer (VisioLink, Bredent GmbH & Co. KG, Senden, Germany). Then the framework was veneered with prefabricated multilayer PMMA composite veneers (novo.lign, Bredent GmbH & Co. KG, Senden, Germany) , using a special PEEK Primer (visio.link, Bredent GmbH & Co. KG, Senden, Germany) and a dual hardening resin (combo.lign, Bredent GmbH & Co. KG, Senden, Germany).

Ninety-two titanium dental implants were placed in total, with 80 implants placed in the maxilla and 12 implants in the mandible. The titanium dental implants used were: 10 BEGO Semados RS implants (BEGO GmbH & Co. KG, Bremen, Germany); 56 blueSKY implants (bredent medical GmbH & Co. KG, Senden, Germany); 12 MPI Excellence implants ASTRA TECH type internal connection (Medical Precision Implants SA, Madrid, Spain); 4 MPI Excellence implants Branemark type external connection (Medical Precision Implants SA, Madrid, Spain); 10 PITT-EASY implants (Sybron Dental Specialities, Bremen, Germany). The surgical procedure to place all the implants and the prostheses was conducted by Dr Siewert in accordance with the recommendations of the manufacturer. Fourteen patients were treated with 67 dental implants placed following a delayed approach with an observed minimum healing period of 4 months; this was prior to loading the definitive PEEK prostheses. The remainder 6 patients and 25 implants were immediately loaded with a 10 piece provisional PMMA screw-retained prostheses with clued in titanium abutments. The definitive PEEK bridge was placed after a minimum of 5 months.

None of the patients had a complete denture as an antagonist. 1 patient had an implant bar retained overdenture, 2 patients had a natural dentition with a removable clasp-retained denture in the molar region, 2 patients a cemented MFC restoration from canine to canine with a removable part attached in the molar region, 1 patient presented a full arch metal-ceramic restoration, 2 patients with a natural dentition and the remaining 12 patients carried in the opposing jaw single or small unit bridge ceramic restorations on natural teeth or implant supported. (Fig 3 to 7) demonstrate a representative case over the observation period.

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

**Clinical and Radiological Assessments.** For bone loss assessment, each patient had extra oral radiographic examinations using an Instrumentarium Orthopantomograph OP100 D Panoramic X Ray (KaVo Dental) to measure marginal bone loss. The panoramic radiographs were taken the day of bridge placement is considered as the baseline radiograph of each patient. From every patient included in the study we made a panoramic x-ray at the end of the observation period. As the study is a clinical retrospective one, the radiographs are only standardized in the way that the x-rays were done in 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) using the following protocol: i) each image was optimized by adjusting bright-

ness, contrast and gamma; ii) each image was then calibrated prior to the length measurements of the mesial and distal aspect (Fig 8A and 8B). In order to improve measurement accuracy the region to be measured was amplified adequately. The distance between the implant shoulder line and the crestal bone line was measured in the distal and mesial side of the implant.

In the recall appointments the clinical examination also assessed the peri-implant tissue health measuring pocket depth and if bleeding occurred. Each patient had a clinical examination to assess peri-implantitis with the dental implants being evaluated as follows cumulative bone loss of  $\geq 2$  mm, depth probing more than 4 mm with simultaneous bleeding and/or suppuration, no implant mobility, and crater-like bone defect<sup>10-15</sup>.

Survival of the implant and prostheses were evaluated where failure was defined as ‘an implant/prostheses that had to be removed for any reason’. Information regarding any adverse events, including condition on onset and measures taken was noted. Adverse events did not always result in removal. Each patient was also examined with respect to the prostheses appearance and abutment and attachment component complications.

At the end of the observation period (end 2016) patients were asked to complete the Oral Health Impact Profile (OHIP-14Sp) using a validated Spanish version<sup>16</sup> and scored using an adaptation of the Likert Scale (0=Least Impact/never, 4=Highest Impact/always). Separately, all 20 patients were asked to score patient satisfaction using a scale of 1 to 10 (1=lowest patient satisfaction/extremely dissatisfied, 10=highest patient 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 survivability.

The dental implant survival rate was high at 99%, with 1 implant out of 92 failing after 7 years in use, observed for 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 all 20 prostheses not failing over the average review period of 56 month ranging from 105 months to 14 months).

**Clinical and Radiological Assessments.** Bone loss was evaluated at a number of time-points post placement of the PEEK prostheses. Bone loss after an average of 54 months (4 years and 6 months) was 0.2mm ( $\pm 1.0$ ) on the mesial aspect and 0.3mm ( $\pm 0.8$ ) on the distal aspect.

Peri-implantitis incidence was low at 1%. Peri-implantitis was observed in 1 dental implant, with the remaining 91 dental implants showing no indication of peri-implantitis during the follow-up period.

Prosthetic complications such as abutment corrosion, abutment decementation or screw loosening were not observed. Chipping of the veneers occurred in 5 cases divided in 2 groups. Early chipping, within the first month after bridge placement due to a mistake in the bonding process occurred in 2 patients (Fig 9A and 9B). After the reparation in the dental laboratory this kind of chipping was not observed any more. In the second group are 3 cases of so called late chipping, single veneer fractures after several years of use and due to changes in the occlusal

pattern (Fig 10), only occurred in the subgroup of bruxers, and all 3 cases could be repaired chair-side in the dental office.

18 patients completed the OHIP-14 questionnaire between October and December 2016, The maximum score for the OHIP-14 is 56 points representing the worst oral health related quality of life result, and the minimum score is 0 points representing best oral health quality of life result. The mean total OHIP-14 score was 3.1 points ( $\pm 3.3$ ) at an average follow-up of 58 months (4 years 10 months) with a range of 0 to 12 points. In addition, 27.8% of patients had a score of 0 and 66.7% of patients had a score of 3 or less. Separately from the OHIP-14 questionnaire, all 20 patients involved in the study were interviewed and asked to score patient satisfaction using a scale of 1 to 10 (1=lowest patient satisfaction/extremely dissatisfied, 10=highest patient satisfaction/extremely satisfied). Patients score patient satisfaction high with a mean score of 9.3 ( $\pm 0.9$ ).

**Bruxism Patients.** A sub-set of 8 patients with bruxism (defined as patients who grind, gnash or clench their teeth) were also identified with an average prostheses treatment time of 51 months. All patients completed the OHIP-14 questionnaire with a mean total OHIP-14 score for this group was also low at 3.9 ( $\pm 3.4$ ). The 8 bruxism patients ranked patient satisfaction at 9.4 (1=lowest patient satisfaction/extremely dissatisfied, 10=highest patient satisfaction/extremely satisfied). The bruxism patients demonstrated 100% dental implant and prostheses survival rate, a low rate of bone loss (0.1 mm  $\pm$  0.8 on the mesial aspect and 0.3 mm  $\pm$  0.8 on the distal aspect), and no incidence of peri-implantitis.

## DISCUSSION

Several studies have reviewed implant and prostheses survival rate of metal implant supported fixed complete full-arch dental prostheses (IFCDPs). The reported percentage of den-

tal implant survival at 5 years is high at 94.3%<sup>17</sup> with the correspondent full-arch prostheses survival rate also high at 91.4%<sup>18,19</sup>. For the 20 patients followed in this study, implant survival rate was at 99% and prostheses survival at 100%. This improved survival of the dental implants and the associated prostheses, might be due to the increased flexibility of the PEEK prosthetic material (lower elastic modulus compared with titanium<sup>20</sup> resulting in an improved shock absorption behavior by the prostheses<sup>21,22</sup>. The improved shock absorption behavior of the PEEK prostheses may shield some of the chewing forces, improving patient comfort and potentially helping to preserve the bone around the dental implants.

The rate of bone loss around dental implants has been reported to be around 0.19 mm per year<sup>23</sup>. After a five year period, it has been reported average marginal bone loss could reach approximately 1.5mm<sup>24</sup>. In the present study much lower bone loss was observed (0.2mm ( $\pm$  1.0) on the mesial aspect and 0.3mm ( $\pm$ 0.8) 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 elasticity module of the veneered PEEK framework bridges are more likely to guarantee a 100% passive fit, compared to 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% of dental implants<sup>17,25</sup>. 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 behavior of the PEEK material. Another element that could benefit the low incidence of peri-implantitis seen is the metal free nature of the PEEK prostheses. Concerns on corrosion and metal ion re-

lease resulting from galvanic coupling of the metallic prostheses with the metallic implant system have been raised <sup>26,27</sup>, and in the present situation such is mitigated by the usage of a metal free prostheses. The natural inertness and biocompatibility of the PEEK material <sup>7</sup>, when combined with the material flexibility allowing a more forgiving passive fit, could also help maintain a long-term healthy tissue.

One case of peri-implantitis was observed for a patient with an early diagnosis of severe periodontitis. Although just one implant of a total of four implants in the lower jaw of this patient was affected. It has been suggested that patients with a diagnosis of periodontitis could be at higher risk of developing peri-implantitis <sup>28-30</sup>.

An outcome which is believed can be greatly improved by improving the shock absorption behavior of the dental implant and prosthetic system is patient's oral health related quality of life <sup>31</sup>. The OHIP-14 questionnaire investigation of 18 patients reported very low average results with 94% of patients scoring to have never or hardly never a problem with pain, and 89% of patients scoring to have never or hardly never a problem with sensitivity or felling unhappy due to teeth issues. The OHIP-14 observations were in-line with the patient satisfaction measure conducted with all 20 patients, who were extremely satisfied ranking satisfaction high at 9.3 (1=lowest patient satisfaction/extremely dissatisfied, 10=highest patient satisfaction/extremely satisfied). 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 <sup>32</sup>. As with the clinical outcomes, patient satisfaction and comfort seemed to be improved by the use of the PEEK prostheses.

The impact that the PEEK prostheses material might have in reducing patient's pain and improving comfort 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 of dental implants and the prostheses resulting in excessive bone loss around the implants, implant failure and even damaged prostheses<sup>33, 34</sup>.

Of the 20 patients followed, a sub-set of 8 patients affected with parafunctions were identified. Parafunction patients OHIP-14 score remained low at 3.9, with these patients ranking satisfaction high at 9.4 (1=lowest patient satisfaction/extremely dissatisfied, 10=highest patient satisfaction/extremely satisfied). The parafunction patients with an average prostheses treatment time of 51 months demonstrated 100% dental implant and prostheses survival rate, a low rate of bone loss (Fig 11A and 11B), 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 for the quality of life and clinical outcomes assessed between the sub-set of parafunction patients and the remaining patients. This seems to indicate that the benefits derived from a more shock absorbing prostheses can be felt even by parafunction patients, and allow for a substantial improvement in their quality of life in comparison with the more rigid metal based prostheses.

## **CONCLUSIONS**

Within the limitations of this study, patients treated with PEEK full-arch implant supported prostheses showed high dental implant and prostheses survival rates with low implant bone loss and incidence of peri-implantitis. Patient oral health related quality of life scores and patient satisfaction was found extremely satisfactory, even for bruxism patients. As veneer chip-

ping presented the only prosthetic complication, we learned that the adherence of the veneers must be done accurate and precisely. On the other hand we have a low incidence of chipping in bruxers, compared with literature, and it is an advantage that the material permit a successful reparation easily, even chairside.

It is suggested that the observed improvements in quality of life 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 dental 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.

**REFERENCES**

1. Bäuml D, Zühr O, Hürzeler MB: Verschraubte Implantatrestauration als prophetisches Konzept. *Implantologie* 2015;23:141-148
2. Wittneben JG, Millen C, Brägger U: Clinical Performance of Screw-Versus Cement-Retained Fixed Implant-Supported Reconstructions- A Systematic Review. *Int J Oral Maxillofac Implants* 2014;29:84-98
3. Zeynep ÖK: Monolithic zirconia: A review of the Literature. *Biomedical Research* 2016; 27:1427-1436
4. Manfredini D, Poggio CE, Lobbezoo F: Is Bruxism a Risk Factor for Dental Implants? A Systematic Review of the Literature. *Clinical Implant Dentistry and Related Research* 2014;16:460-469
5. Papaspyridakos P, Chen CJ, Chuang K et al: A systematic review of biologic and technical complications with fixed implant rehabilitations for edentulous patients. *Int J Oral Maxillofac Implants* 2012;27:102-110
6. Rosentritt M, Schneider-Feyrer S, Behr M et al: In Vitro Shock Absorption Tests on Implant-Supported Crowns: Influence of crown Materials and Luting Agents. *Int J Oral Maxillofac Implants* 2018; 33:116-122
7. Jarman-Smith M: Evolving uses for implantable PEEK and PEEK based compounds. *Med Device Technol* 2008;9:12-17
8. Santing HJ, Meijer HJA, Raghoobar GM et al: Fracture Strength and Failure Mode of Maxillary Implant-Supported Provisional Single Crowns: A Comparison of Composite resin crowns Fabricated Directly Over PEEK Abutments and Solid Titanium Abutments. *Clin Implant Dentistry* 2012;14:882-889

9. Siewert B: Production of Implant Supported Bridges from PEEK Blanks. *DZW Die Zahnarzt Woche Digital Dental News* 2013;10:22-31
10. Lang NP, Mombelli A, Tonetti MS et al: Clinical trials on therapies for peri-implant infections. *Ann Periodontol* 1997;2:343-356
11. Lang NP, Berglundh T: Periimplant diseases: where are we now? Consensus of the Seventh European Workshop on Periodontology. *J Clin Periodontol* 2011;38:178-181
12. Lindhe J, Merle J: Peri-implant diseases: Consensus Report of the Sixth European Workshop on Periodontology. *J Clin Periodontol* 2008;35:282-285
13. Mombelli A, Müller N, Cionca N: The epidemiology of peri-implantitis. *Clin Oral Implants Res* 2012;23:67-76
14. Tomasi C, Derks J: Clinical research of peri-implant diseases - Quality of reporting, case definitions and methods to study incidence, prevalence and risk factors of peri-implant diseases. *J Clin Periodontol* 2012;39:207-223
15. Zitzmann NU, Berglundh T: Definition and prevalence of peri-implant diseases. *J Clin Periodontol* 2008;35:286-291
16. León S, Bravo-Cavicchioli D, Correa-Beltrán G: Validation of the Spanish version of the Oral Health Impact Profile (OHIP-14Sp) in elderly Chileans. *BMC Oral Health* 2014;14:95
17. Aglietta M, Siciliano VI, Zwahlen M, et al: A systematic review of the survival and complication rates of implant supported fixed dental prostheses with cantilever extensions after an observation period of at least 5 years. *Clin Oral Implants Res* 2009;20:441-451
18. Pjetursson BE, Brägger U, Lang NP, et al: Comparison of survival and complication rates of tooth-supported fixed dental prostheses (FDPs) and implant-supported FDPs and single crowns (SCs). *Clin Oral Implants Res* 2007;18:97-113

19. Berglundh T, Persson L, Klinge B: A systematic review of the incidence of biological and technical complications in implant dentistry reported in prospective longitudinal studies of at least 5 years. *J Clin Periodontol* 2002;29:197-212
20. Rho JY, Ashman RB, Turner CH: Young's modulus of trabecular and cortical bone material: ultrasonic and micro tensile measurements . *J Biomech* 1993;26:111–119
21. Skalak R: Biomechanical considerations in osseointegrated prostheses. *J Prosthet Dent* 1983;6:843-848
22. Menini M, Conserva E, Tealdo T, et al: Shock absorbing capacity of restorative materials for dental implant prostheses: An in vitro study. *Int J Prosthodont* 2013;26:549-556
23. Geraets W, Zhang L, Liu Y, et al. Annual bone loss and success rates of dental implants based on radiographic measurements. *Dentomaxillofac Radiol* 2014;43:20140007
24. Koller CD, Pereira-Cenci T, Boscatto N: Parameters associated with marginal bone loss around implant after prosthetic loading. *Braz Dent J* 2016;27:292-297
25. Heitz-Mayfield LJ, Mombelli A: The therapy of peri-implantitis: a systematic review. *Int J Oral Maxillofac Implants*. 2014;29:325–345
26. Alrabeah GO, Knowles JC, Petridis H: The effect of platform switching on the levels of metal ion release from different implant–abutment couples. *Int J Oral Sci* 2016;8:117–125
27. Oh KT, Kim KN: Electrochemical properties of suprastructures galvanically coupled to a titanium implant. *J Biomed Mater Res* 2004;70:318-331
28. Hardt CR, Gröndahl K, Lekholm U, et al: Outcome of implant therapy in relation to experienced loss of periodontal bone support: a retrospective 5- year study. *Clin Oral Implants Res* 2002;13:488-494
29. Karoussis IK, Salvi GE, Heitz-Mayfield LJ, et al: Long-term implant prognosis in patients

with and without a history of chronic periodontitis: a 10-year prospective cohort study of the ITI Dental Implant System. *Clin Oral Implants Res* 2003;14:329-339

30. Schou S, Holmstrup P, Worthington HV, et al: Outcome of implant therapy in patients with previous tooth loss due to periodontitis. *Clin Oral Implants Res* 2006;17:104-123

31. Oh SH, Kim Y, Park JY, et al: Comparison of fixed implant-supported prostheses, removable implant-supported prostheses, and complete dentures: patient satisfaction and oral health-related quality of life. *Clin Oral Implants Res* 2014;27:1-7

32. Babbush CA: Posttreatment quantification of patient experiences with full-arch implant treatment using a modification of the OHIP-14 questionnaire. *J Oral Implantol* 2012;38:251-260

33. Misch CE: Density of bone: effect on treatment plans, surgical approach, healing and progressive bone loading. *Int J Oral Implantol* 1990;6:23-31

34. Jemt T, Lindén B, Lekholm U: Failures and complications in 127 consecutively placed fixed partial prostheses supported by Branemark implants: from prosthetic treatment to first annual checkup. *Int J Oral Maxillofac Implants* 1992;7:40-44

## FIGURES

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



Figure 2: Laboratory occlusal view of a veneered PEEK framework with four occlusal screws



Figure 3: Initial situation prior to prostheses placement, occlusal view (June 2008)



Figure 4: Full arch screw retained prostheses with PEEK framework in place, occlusal view(June 2008)



Figure 5: The same prostheses than in Figure 4 in recall appointment after 8 years (October 2016)



Figure 6: Panoramic radiography in recall appointment 8 years after insertion (October 2016)

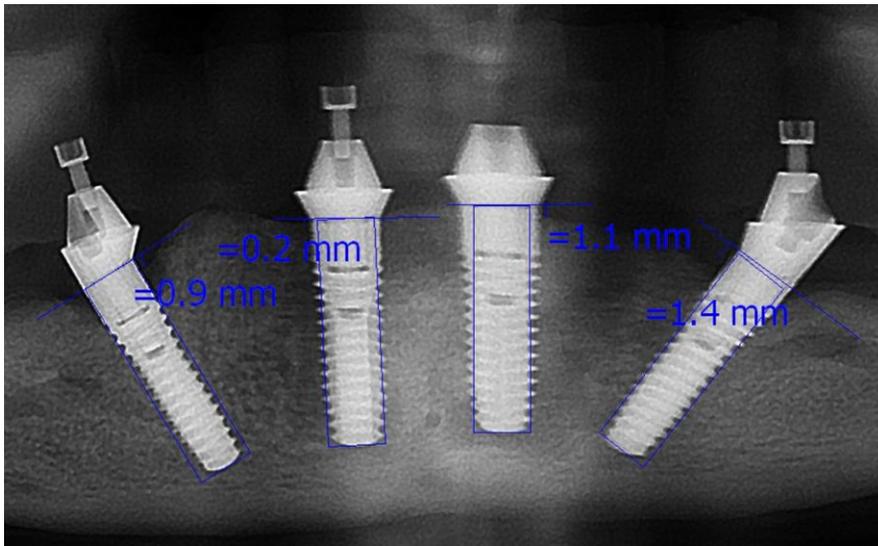


Figure 7: Situation with prostheses removed in recall appointment 8 years after insertion (October 2016)



Figure 8: Representative example case for the measurement protocol of the mesial and distal peri-implant bone levels in detail of the panoramic radiography

A: Initial reference when the definitive restoration was installed after calibration process (September 2013)



B: Final reference at the end of the observation period after calibration process (November 2016)

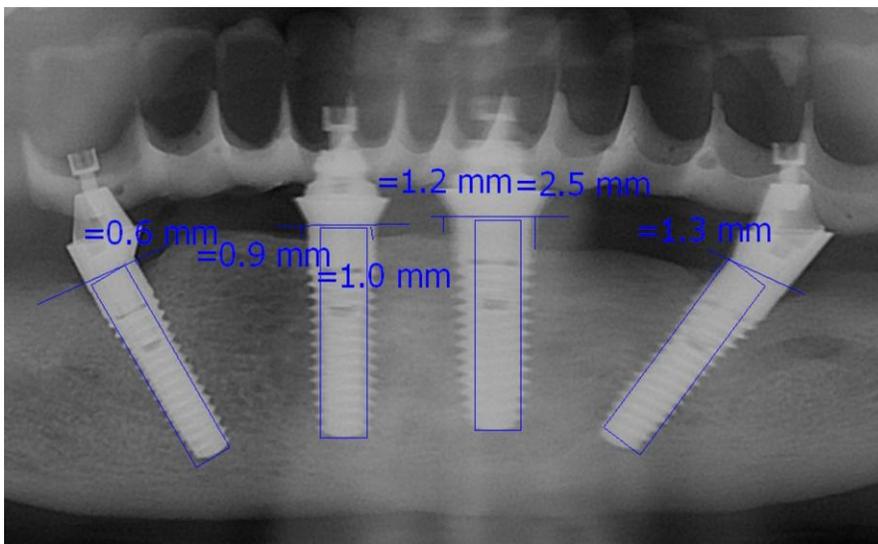


Figure 9A and 9B Examples of early veneer chipping (within the first 1 month of placement).

This was determined to be from an error in the laboratory bonding process.



Figure 10: Examples of late veneer chipping, 6 years after placement, caused by occlusal abrasion of the PMMA veneers



Figure 11A Panoramic radiography of a patient with bruxism at 4 months follow up after pros-

theses placement

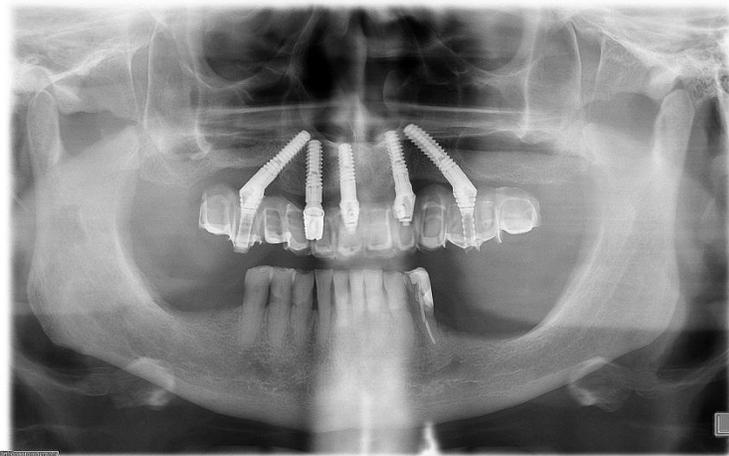


Figure 11B Panoramic radiography of the same patient at 70 months follow up after prostheses placement

