Marco Roy*, Adam Piosik, Wieslaw Hedzelek

Photofunctionalization: full-arch immediate loading rehabilitation — case report

Fotofunkcjonalizacja: rehabilitacja pełnego łuku zębowego z natychmiastowym obciążeniem — opis przypadku

Prosthodontic Department, Poznan University of Medical Sciences, Poland

DOI: http://dx.doi.org/10.20883/df.2018.32

ABSTRACT

Dental implantology is the most physiological method to rehabilitate the partial or complete edentulous patients. The success is dependent on the level of integration between the fixture and bone, also known as BIC (bone to implant contact). After implantation the fixture is healing in the bone in a process known as osteointegration in which the primary stability, which is a mechanic stability, is replaced with the secondary stability which occur as a biological connection between the cells and the fixture. If during placement of the implant the clinician can achieve a good primary stability; meaning a tightening force of 35 N/cm it is possible to load the implant with a temporary restoration during the healing process. UVC photofunctionalization has been introduced as a valid method to speed up healing process and achieve a greater BIC. In the case presented the authors are showing the benefits of photofunctionalizing dental implants to improve the stability and outcomes in a full arch with simultaneous extractions, implant placement and loading.

Keywords: photofunctionalization, Implantology, Immediate loading, cantilevered from implants, UVC irradiation.

STRESZCZENIE

Leczenie implantologiczne jest uznane za najbardziej fizjologiczną metodę w rehabilitacji częściowych i całkowitych braków zębowych. Sukces zależy od stopnia integracji implantu z tkanką kostną, określany mianem BIC (bone to implant contact). Po wszczepieniu implantu zachodzi proces osseointegracji. W pierwszej fazie osseointegracji powstaje stabilizacja pierwotna, która jest stabilizacją mechaniczną, jest ona zastępowana przez stabilizację wtórną, będącą biologicznym połączeniem pomiędzy komórkami organizmu, a implantem. Jeżeli w trakcie wszczepiania implantu zostanie osiągnięta pierwotna stabilizacja na poziomie 35 N/cm siły dokręcającej, możliwe jest na czas gojenia, obciążenie natychmiastowe implantów protetyczną rekonstrukcją tymczasową. Fotofunkcjonalizacja UVC została zastosowana jako sprawdzona metoda przyspieszająca proces gojenia oraz osiągniecie większego stopnia BIC. W obecnym przypadku autorzy zaprezentowali korzyści leczenia płynące z fotofunkcjonalizacji implantów dentystycznych dla zwiększenia stabilizacji oraz końcowego rezultatu w rekonstrukcji pełnego łuku zębowego, z jednoczesnymi ekstrakcjami i implantacjami, oraz obciążeniem natychmiastowym, w niekorzystnych warunkach klinicznych.

Słowa kluczowe: fotofunkcjonalizacja, implantologia, natychmiastowe obciążenia, przęsło dystalne na implantach, naświetlanie UVC.

Introduction

Nowadays restoring missing teeth with implants is becoming the gold standard, this being the most similar to nature solution when compared to physiological conditions. A thorough planning of the edentulous area is necessary to discuss and choose the right prosthetic option. Since the beginning of dental implantology a lot of effort has been put in improving the success rate and techniques. In literature many protocols have been described for surgical placement and prosthetical loading of implants. It still is under debate if it should be done as a one-stage procedure or as a two-stage procedure [1, 2]. Branemark et al [3] in their studies recommended a two stage technique while, in the last 15 years it has been reported that immediate loading is equally effective [1]. In order though to immediately load an implant, it is necessary to achieve a good primary stability. The implant should be able to withstand a tightening force of 35N/cm

without further rotation in order to load [4]. During the osteointegration process, the loss of primary stability is known to be faster than the development of the secondary stability which causes a gap between the phases also known as stability dip [5].

Ostman et al. [6] report no difference in single versus two stage technique success as long as the implant is initially stable. The success in implantology however is related to the level of osteointegration achieved as a result of the healing process. The higher the connection between the bone and the implant surface, also described as BIC (bone to implant contact), the better osteointegration is achieved. Thanks to RFA (resonance frequency analysis) it is possible to appreciate the level of osteointegration. As a general rule an implant showing an RFA ≥ 60 can be prosthetically restored. No matter the technique or the different surface modification to which the implants undergo, the BIC range value is between 50 to 75%. Recently, UVC photofunctionalization has been introduced as a valid method to modify the physic-chemical properties of titanium, namely making the surface super-hydrophilic thanks to the reduction of carbon contamination [7, 8]. The phenomena has proven to enhance protein and cell attachment/activity and in turn speed up the process of osteointegration and BIC to almost 100% [7]. Titanium surfaces after manufacturing undergo a process of biological ageing, that is the inevitable deposition of hydrocarbons, with the effect of blocking some binding sites for cell attachment. Therefore, the energy of the UVC is able to break the bonds between hydrocarbons and titanium, in turn removing the contaminants adsorbed on the titanium surface. Overall cell attachment is greatly enhanced as it is the process of osseointegration [7–9] (**Figure 1**). It is imperative that the clinicians performs the photofunctionalization of the implants chairside with a dedicated UVC device (**Figure 5**) with a cycle of 12 minutes maximum 2 hours before the implants placement. Otherwise the process of biological ageing would take place and re-contaminate the surface.

To our knowledge it has been published only one article before about a case of immediate loading after UVC photofunctionalization [10]. Then, the aim of this article is to present a case report of a full arch temporary fixed prosthesis, with immediate loading through the use of photofunctionalized implants so as to increase implant primary stability and BIC and to decrease the time necessary for osteointegration to take place.

Case presentation

The patient was a 41 year old, white female with no significant medical history. She presented diffuse pain in the maxilla and inability to chew due to diffuse tooth mobility. Radiographic examination (**Figure 2**) revealed both periodontal bone reabsorption and periapical radiolucencies in both maxilla and mandible affecting teeth No. (16, 15,

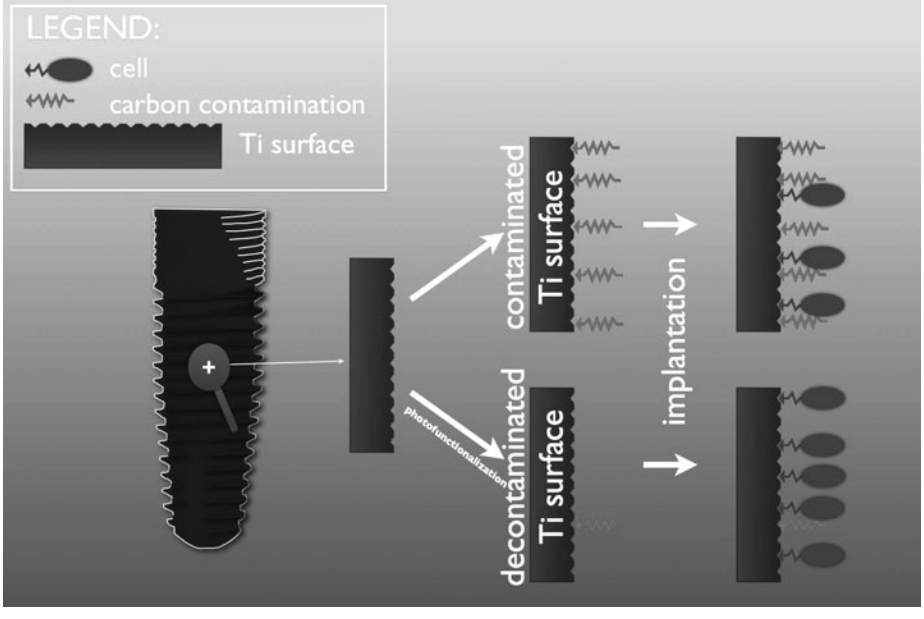

Figure 1. Scheme of the effect of photofunctionalization. Removing the hydrocarbon chains present on the implant surface creates binding sites for the outer surface proteins of the cells

Rycina 1. *Schemat efektu fotofunkcjonalizacji. Usuwanie łańcuchów węglowodorowych obecnych na powierzchni implantu stwarza dostęp dla protein powierzchniowych komórek*

14, 13, 12, 11, 21, 22, 23, 25, 37, 36, 35, 44, 45) and the presence of restorative screws in the upper incisors. During clinical examination (**Figure 3**) the teeth revealed a class 3 mobility. The patient reported to have personally glued, with commercially available glue, the teeth back into position to try and avoid going for a professional dental visit. Masticatory function was not at all possible, the patient fed herself only with mashed food using the tongue and palate to chew and swallow. To restore patient physiologic dental function and aesthetics a treatment plan was formulated to extract any teeth which were no longer restorable prosthetically and for those that were too compromised periodontally. This was to be followed by immediate placement of implants with immediate loading taking place through the use of temporary immediate fixed prosthetics.

First step was endodontic treatment of tooth No. 16 followed by crown preparation. Then bite registration was performed as two stage procedure: one before the surgical part and the second afterwards. Bis-acrylic material, was used during the first stage of bite registration (**Figure 6 c**); usually this material is dedicated for temporary crowns fabrication (Luxatemp, DMG). However, the stiffness of this material enables copying of patient's habitual bite.

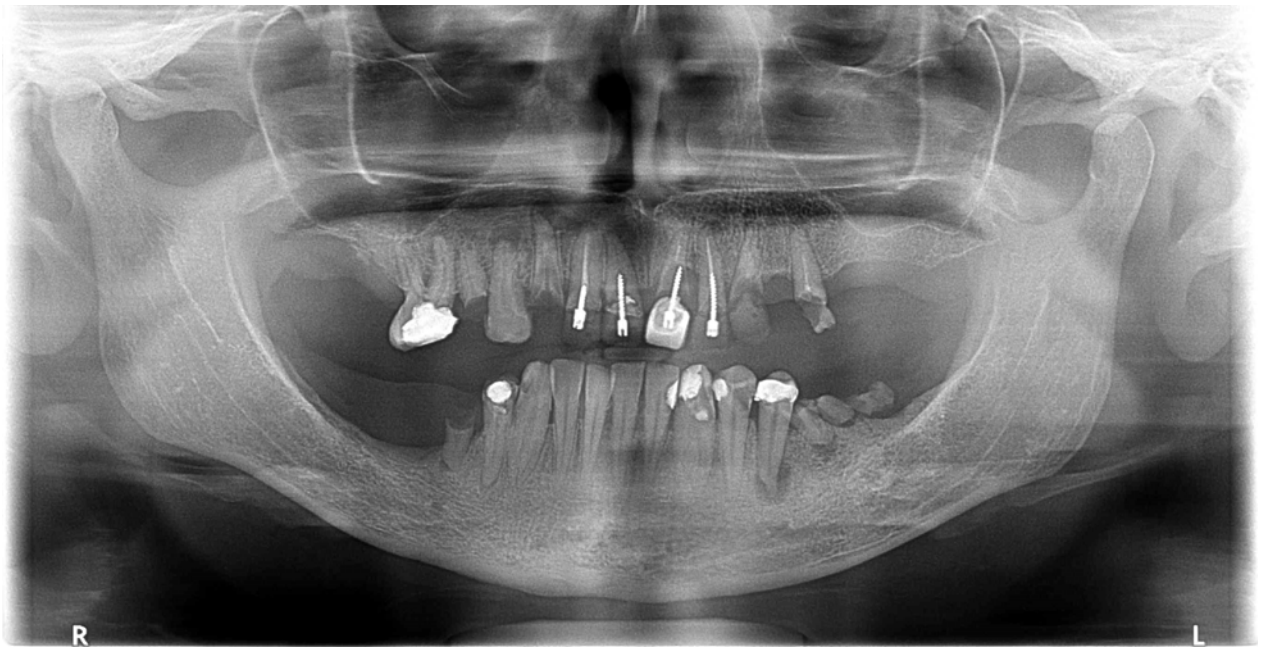

Figure 2. Panoramic x-ray before treatment

Rycina 2. *Zdjęcie rentgenowskie panoramiczne przed leczeniem*

Figure 3. Intraoral view before treatment

Rycina 3. *Zdjęcie wewnątrzustne przed leczeniem*

Figure 4. Upper arch after extractions and implants placement

Rycina 4. *Zdjęcie wewnątrzustne — wyrostek zębodołowy szczęki po ekstrakcji zębów oraz wszczepieniu implantów*

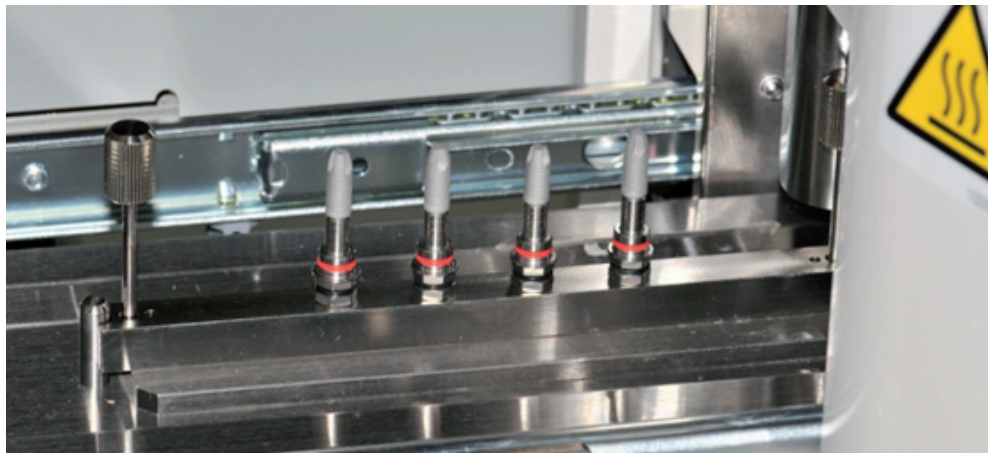

Figure 5. Implants on stand after UVC Photofunctionalization treatment

Rycina 5. *Implanty w statywie po fotofunkcjonalizacji UVC*

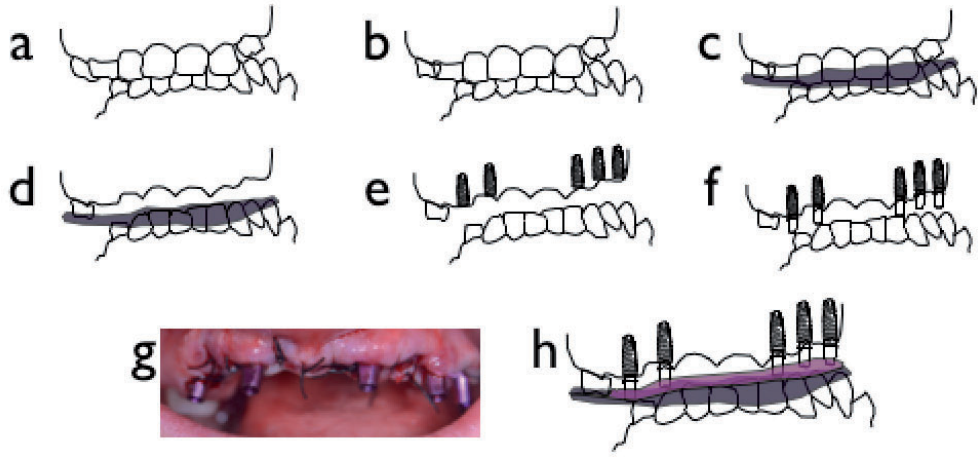

Figure 6. Bite registration on implants impressions transfers: a) Habitual bite. b) After preparation tooth 16 for crown. c) Bite registration first layer with Luxatemp. d) Extraction of hopeless teeth. e) Implants after surgery. f–g) Implants with impressions transfers. h) Bite registration with second layer, from silicone material and impressions transfers

Rycina 6. *Rejstracja zwarcia na implantologicznych transferach wyciskowych: a) Zgryz nawykowy. b) Ząb 16 po opracowaniu pod koronę protetyczną. c) Pierwsza warstwa rejestratu zwarciowego, z materiału Luxatemp. d) Wyrostek zębodołowy szczęki po ekstrakcjach zębów. e) Wszczepienie implantów. f–g) Transfery wyciskowe zamontwane do implantów. h) Druga warstwa rejestratu zwarciowego wykonana materiałem silikonowym*

Then during the surgical part of the treatment the teeth No. 15, 14, 13, 12, 11, 21, 22, 23, 25, were extracted then a full thickness flap was raised. After which 5 implants (MIS ®C1) were placed in the maxilla in areas 14, 12, 22, 24, 26 (**Figure 4**, **Figure 6 e**). Photofunctionalization of the implants, with Ushio TheraBeam® SuperOsseo (**Figure 5**), was performed to achieve a better BIC and in turn achieve a greater stability. Implant stability was recorded using the Osstell RFA (Resonance frequency analysis) the values are reported in a chart (**Figure 7**).

Only after surgery the second part of bite registration was performed. That is, short impressions transfers, snap on type (MIS®), were connected to the freshly placed implants, with the aim of "mimicking natural abutments after crowns preparation" (**Figure 6 f** and **Figure 6 g**). With a combination of bis-acrylic layer taken during the first stage and bite registration silicone material placed during the second phase, patients bite was stable onto tooth 16 and implant impressions transfers (14, 12, 22, 24, 26) (**Figure 6 h**). Thus with one appointment all

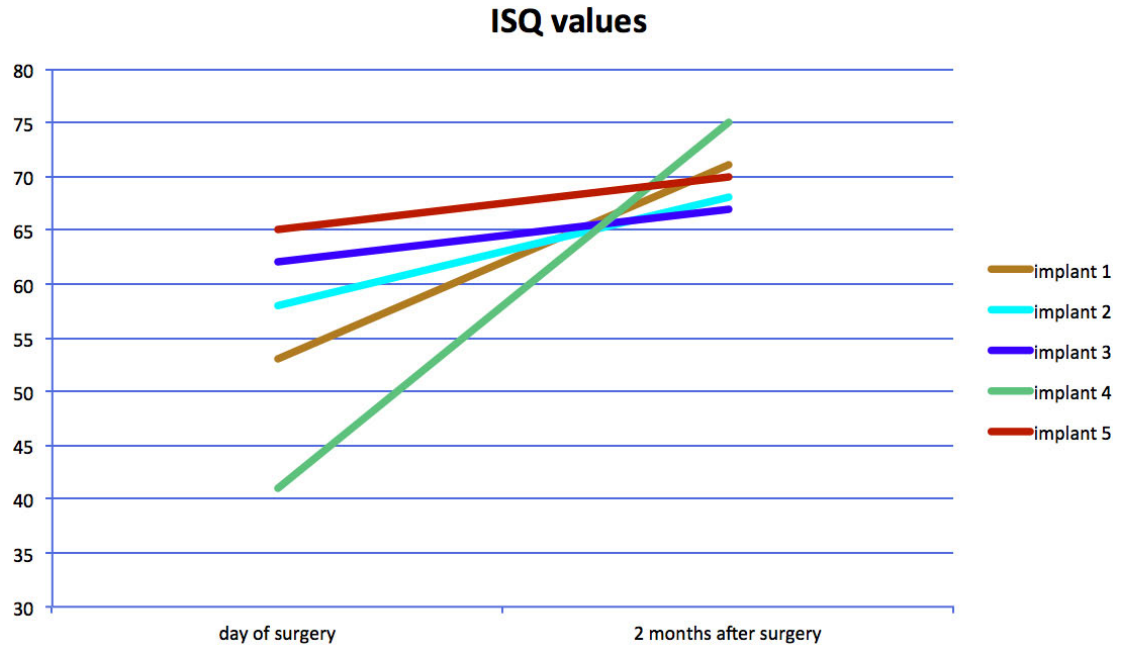

Figure 7. Diagram of ISQ values on the day of surgery and 2 months after surgery

Rycina 7. *Diagram uzyskanych wartości ISQ w dniu zabiegu oraz 2 miesiące później*

Figure 8. Final upper bridge

Rycina 8. *Zdjęcie wewnątrzustne — efekt końcowy*

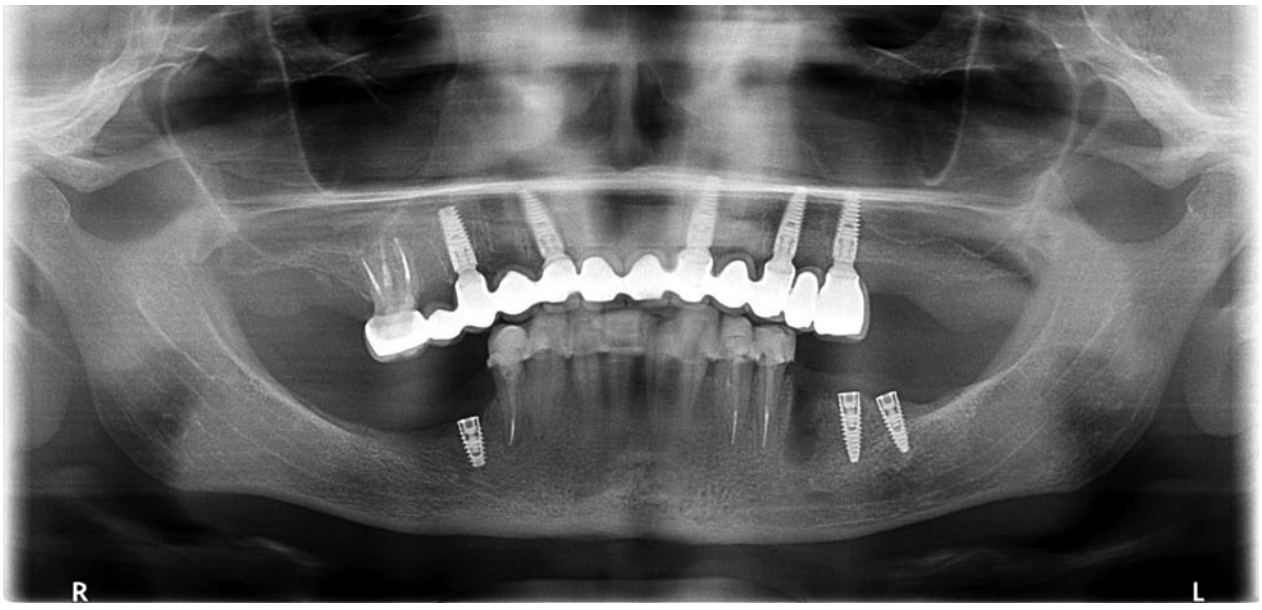

Figure 9. Panoramic x-ray with temporary upper bridge and implants in lower jaw

Rycina 9. *Zdjęcie radiologiczne panoramiczne z tymczasowym mostem w szczęce oraz wszczepione implanty w żuchwie*

the prosthodontics procedures (impressions, precise bite registration and an arbitrary axis transfer with Kavo anatomical face bow) could have been performed in the same day of the surgery (extractions and immediate implantations). Then the impressions transfers were removed and the healing abutments were screwed to the implants (**Figure 3**). Impressions were send, together with all the appropriate information and photographs to dental technician, to fabricate the temporary bridge. To ensure appropriate stiffness of the bridge and implants splinting effect, during the healing period the team of clinicians decided for porcelain fused to metal cemented temporary bridge on titanium abutments. The temporary ceramic fused to metal bridge (16-X-14i-X-12i-X-X-22i-X-24i-X-26i) was delivered within 48 hours after the placement of the implants. It was cemented (Temp Bond, Kerr) with special care not to leave any cement remnants. After rehabilitating the upper arch the second part of treatment was then focused on the lower arch starting with endodontic treatment of teeth 44, 33, 34, preparation for crowns on 44, 43, 42, 41, 31, 32, 33, 34. On the same appointment impressions for long term temporary bridge and bite registration in a standard protocol were taken, followed by placement of a chair side fabricated temporary bridge 44-43-42-41-31-32-33-34 on a temporary cement (Temp Bond, Kerr). Subsequently extraction of teeth 45 35 36 37 was performed and 3 implants (MIS® C1) were placed in positions 36, 37, 45 with the standard protocol. The laboratory produced a temporary metal ceramic bridge X-X-44-43-42-41-31-32-33-34-35-X which was delivered to the patient after 1 week.

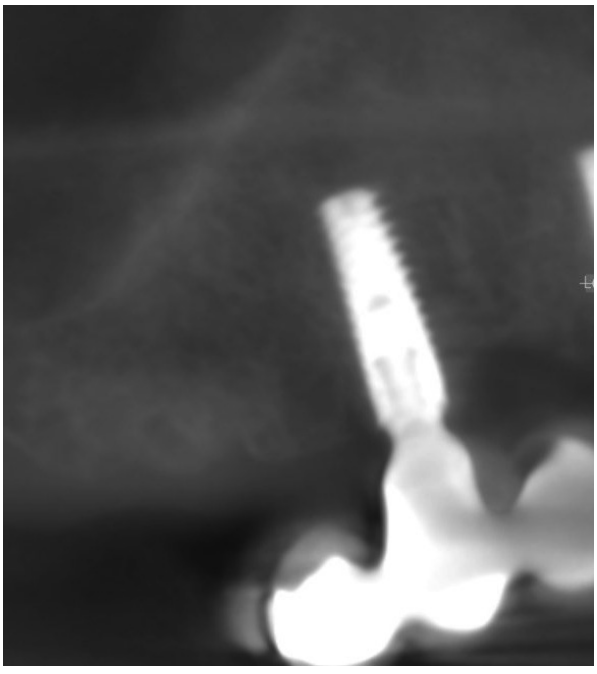

Figure 10. CBCT scan after 4 months of healing period in region 16

Rycina 10. *Zdjęcie radiologiczne CBCT po 4 miesiącach gojenia po ekstrakcji zęba 16*

The patient was advised to adhere to a strictly soft diet so as to avoid placing any strong occlusal forces on the surgical sites. Thanks to past patient history high compliance was observed by her. When comparing the patient at completion of the procedure and 2 weeks post-operatively, the soft-tissues looked in relatively good health. After

2 months from the day of the surgery the upper bridge was removed, the Osstell data taken shows that successful osteointegration has taken place (**Figure 7**). The temporary bridge was then replaced with permanent porcelain fused to metal bridge (**Figure 8** and **Figure 9**). The patient was also educated with step-by-step instructions on how to improve the oral hygiene to ensure a long-term result [11]. After 2 more months also final porcelain fused to metal cemented bridges on titanium abutments were delivered in a lower arch. Patient liked so much lower bridge in the area of the lower teeth, that she refused changing them. In the fact crowns were perfectly sealed, in good function and esthetics, we could respect patients wish. With small modifications, and four additional crowns on healed implants in the mandible, prosthetic crowns were cemented on Ketac Cem Plus cement (3M Espe). Thanks to the high implant stability achieved with the UVC conditioning of the implants it was possible do deliver distal pontic to an implant even thou Kim et al. [12] have reported no statistically difference in terms of survival rate with single implant supported cantilever FPDs even in

Figure 11. Panoramic x-ray after two years recall

Rycina 11. *Zdjęcie radiologiczne panoramiczne po dwóch latach obserwacji*

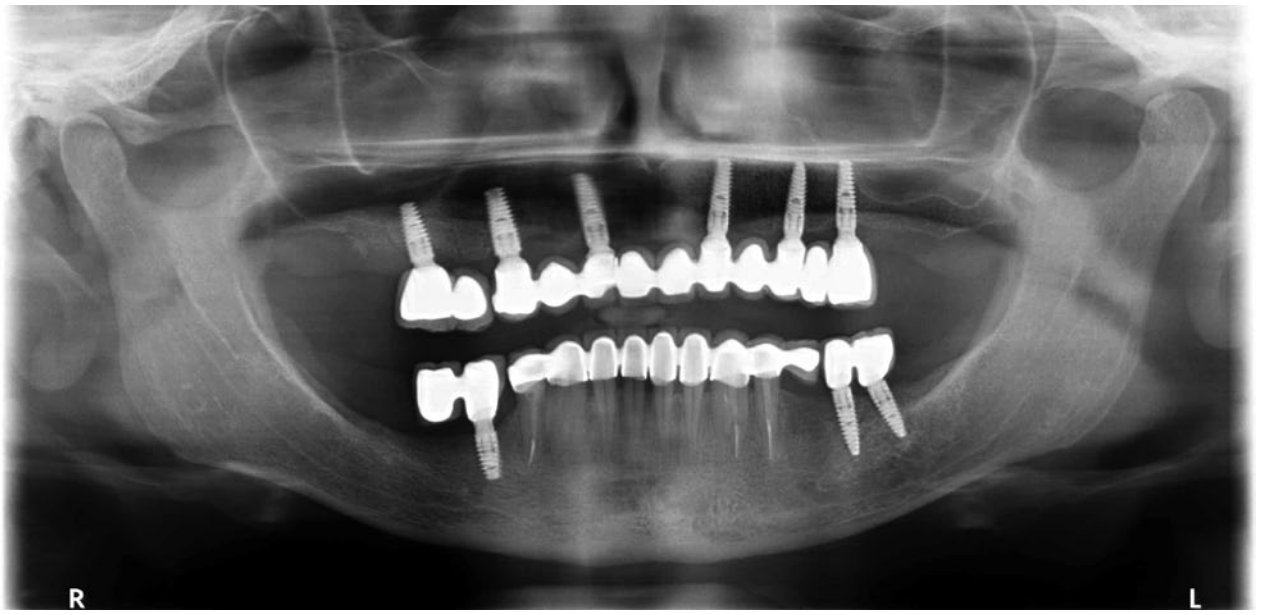

Figure 12. Panoramic x-ray after two and a half years recall

Rycina 12. *Zdjęcie radiologiczne panoramiczne po dwóch latach i pół roku obserwacji*

standard conditions. After one year recall additional problems occurred regarding the abutment tooth 16. Patient referred pain of that tooth for 4 days with no remissions, during the clinical examination pain was confirmed. Decision of extraction tooth 16 was taken, and after 4 months of healing (**Figure 10**) an implant was placed (**Figure 11**). Due to bone remodeling after extraction of tooth 16, a big gap formed between the pontic tooth 15 and the gum. Thus, the pontic on 15 was cut from the abutment implant on 14 and replaced as a pontic with abutment 16 (**Figure 12**).

Discussion

This case is an example of the use of photofunctionalization in the clinical practice. Even though in conditions of poor bone and multiple extractions, all implants demonstrated successful osteointegration with healthy soft tissue being present. Typically the drawback of immediate loading is the poor bone quality or the missing cortical anchorage, which are known to reduce the strength of osteointegration by even 60% [13]. However, in animal studies photofunctionalized implants, placed in the same conditions as control group, have been reported to achieve the same anchorage as the ones with cortical support [14]. Implant placement in a fresh extraction socket, is known to be very challenging situation for the osteointegration process, and it is associated with a higher implant failure rate than when placement takes place into a healed site [15]. If failure occurs it usually takes place during the early stage of healing, therefore implants placed into a fresh extraction socket should be kept unloaded for at least 4 months. It is then noteworthy that, in the present case, we were able to load immediately the implants with a fixed bridge. Moreover in this case diffuse inflammation was present before implantation, this being a known negative factor which can lower the success rate to as low as 70% [16]. We believe that the higher level of osteoblastic activity induced by photofunctionalization is able to overcome some of the potentially negative factors present. Earlier in the text, it was underlined the importance of a good primary stability (mechanical stability), especially if immediate loading is planned, which in turn then leads to successful secondary stability, namely osteointegration. If during this healing process the RFA is performed it is possible to appreciate a dip in the values, interpreted as a temporary lowering of implant stability occurring while the primary stability is changing to secondary stability. Due to this temporary decrease in stability, immediate loading is usually performed in dense bone D1 and D2, where a higher level of primary stability can be achieved. According to literature bone density can either be evaluated before surgery by computerized tomography scan Hounsfield values, by estimation by arch location or during surgery by tactile sense of the surgeon, or by the torque indicator in the handpiece system [17]. In our case the bone density was very poor, considering that the torque of insertion was below 35 N/cm making it very challenging. After performing photofunctionalization of the implants it seems possible to shorten the time this process lasts or even make it become a single process with almost no transitional stability dip [18, 19]. It is of great interest the changes in RFA values we obtained, as the highest value is recorded for the implant with the lowest starting point at the day of the surgery. The potential advantage of photofunctionalized implants in inducing osteointegration, can help overcoming the compromised healing environment. Moreover, reduced loading capacity of short implants and a lack of cortical support should not be a drawback for implant placements or immediate loading when the implants are photofunctionalized.

In the case presented in this article the authors decided to follow the immediate loading protocol. However, the patient was provided with alternative such as, extraction of the hopeless teeth and full denture in the upper arch and partial in the lower. Otherwise placement of four implants to stabilize an overdenture [20]. Authors were also considering a standard protocol of implantation in maxilla, with delayed loading. But in fact that patients needed to have at least a temporary full denture in the upper arch and during the mastication she would had compressed the implants during the healing process. With this in mind and with patients agreement, we decided to follow an immediate loading and splinting of multiple implants with the remaining tooth 16. This solution gave better comfort and self-confidence increasing patient quality of life from the very beginning of treatment. The follow up of two and half years seems to confirm the right protocol decision.

Conclusions

Full arch immediate loading seems to be possible even in cases with difficult anatomy and post-extraction sockets. UVC Photofunctionalization positively influenced the osteointegration capacity of the titanium dental implants making implant success easier to be achieved along with immediate loading made possible. But research on a larger

scale needs to be performed to dictate exactly how it is possible to shorten the healing time after photofunctionalization. However, in our case we believe that it was useful in speeding up the process of osteointegration based on the results of our RFA (resonance frequency analysis) values. Moreover, it was possible to provide a good aesthetic result immediately after the surgical procedure.

Acknowledgements

Conflict of interest statement
The authors declare that there is no conflict of interest in the authorship or publication of contribution.

Funding sources
There are no sources of funding to declare.

References

[1] Tallarico M, Vaccarella A, Marzi GC. Clinical and radiological outcomes of 1- versus 2-stage implant placement: 1-year results of a randomised clinical trial. Eur J Oral Implantol. 2011;4(1):13–20.
[2] Cardelli P, Belletti M, Murmura G. Immediate postextraction implant with simultaneous buccal plate augmentation, restored with lithium disilicate abutment and veneer: a clinical report. Quintessence Int. 2014;45(9):757–62.
[3] Branemark PI, Breine U, Adell L, Hanson BO, Lindstrom J, Ohlsson. Intra-osseous anchorage of dental prostheses. I. Experimental studies. Scand J Plast Reconstr Surg. 1969;3(2):81–100.
[4] Malo P, Rangert B, Dvarsater L. Immediate function of Branemark implants in the esthetic zone: a retrospective clinical study with 6 months to 4 years of follow-up. Clin Implant Dent Relat Res. 2000;2(3): 138–46.
[5] Barndt P, Zhang H, Liu F. Immediate loading: From biology to biomechanics. Report of the Committee on Research in Fixed Prosthodontics of the American Academy of Fixed Prosthodontics. J Prosthet Dent. 2015 Feb;113(2):96–107.
[6] Ostman PO, Hellman M, Sennerby L. Direct implant loading in the edentulous maxilla using a bone density-adapted surgical protocol and primary implant stability criteria for inclusion. Clin Implant Dent Relat Res. 2005;7(Suppl. 1):60–9.
[7] Roy M, Hędzelek W. Photofunctionalization: a new method to bio-activate the titanium implant surface — review of literature. Journal of Stomatology (Czasopismo Stomatologiczne). 2014;67(5):682–691.
[8] Roy M, Pompella A, Kubacki J, Szade J, Roy RA, Hędzelek W. Photofunctionalization of Titanium: An Alternative Explanation of Its Chemical-Physical Mechanism. PLoS ONE. 2016;11(6):e0157481.
[9] Roy M, Pompella A, Kubacki J, Piosik A, Psiuk B, Klimontko J, Szade J, Roy RA, Hędzelek W. Photofunctionalization of dental zirconia oxide: Surface modification to improve bio-integration preserving crystal stability. Colloids Surf B Biointerfaces. 2017; 156: 94-202.
[10] Suzuki S, Kobayashi H, Ogawa T. Implant stability change and osseointegration speed of immediately loaded and photofunctionalized implants. Implant Dent. 2013;22(5):481–90.
[11] Kwon T, Levin L. Cause-related therapy: a review and suggested guidelines. Quintessence Int. 2014;45(7): 585–91.
[12] Kim P, Ivanovski S, Latcham N, Mattheos N. The impact of cantilevers on biological and technical success outcomes of implant-supported fixed partial dentures. A retrospective cohort study. Clin Oral Implants Res. 2014;25(2):175–84.
[13] Ueno T, Yamada M, Suzuki T, Minamikawa H, Sato N, Hori N, Takeuchi K, Hattori M, Ogawa T. Enhancement of bone-titanium integration profile with UV-photofunctionalized titanium in a gap healing model. Biomaterials. 2010;31(7):1546–57.
[14] Funato A, Yamada M, Ogawa T. Success rate, healing time, and implant stability of photofunctionalized dental implants. Int J Oral Maxillofac Implants. 2013; 28(5):1261–71.
[15] Deng F, Zhang H, Zhang H, Shao H, He Q, Zhang P. A comparison of clinical outcomes for implants placed in fresh extraction sockets versus healed sites in periodontally compromised patients: a 1-year follow-up report. Int J Oral Maxillofac Implants. 2010; 25(5):1036–40.
[16] Grossmann Y, Levin L. Success and survival of single dental implants placed in sites of previously failed implants. J Periodontol. 2007;78(9):1670–4.
[17] Misch CE, Dietsh-Misch F, Hoar J, Beck G, Hazen R, Misch CM. A Bone Quality–Based Implant System: First Year of Prosthetic Loading. Journal of Oral Implantology. 1999;25(3):185–197.
[18] Abrahamsson I, Berglundh T, Linder E, Lang NP Lindhe J. Early bone formation adjacent to rough and turned endosseous implant surfaces. An experimental study in the dog. Clin Oral Implants Res. 2004;15(4):381–92.
[19] Gonzalez-Garcia R, Monje F, Moreno-Garcia C. Predictability of the resonance frequency analysis in the survival of dental implants placed in the anterior non-atrophied edentulous mandible. Med Oral Patol Oral Cir Bucal. 2011;16(5):664–9.
[20] Roy M, Idzior-Haufa M, Hedzelek W. Precision Attachments: A Review to Guide Clinicians. Dental and Medical Problems. 2016;53(4):559–565.

Acceptance for editing: 2018-10-16
Acceptance for publication: 2018-12-05

*** Correspondence Author:**
Marco Roy
Prosthodontic Department
Poznan University of Medical Sciences
70 Bukowska Street, 60-812 Poznan, Poland