Additively Custom-made 3D Printed Subperiosteal Implants for the rehabilitation of the Severely Atrophic Maxilla (a case report)

Mahnaz Arshad[1], Nourin Khoramshahi [1], and Gholamreza Shirani[1]

[1]Tehran University of Medical Sciences

June 28, 2022

Abstract

In the past decade, on account of computer-aided prosthetic manufacturing techniques, subperiosteal implants were introduced as a safe option for patients with compromised alveolar ridges. We present 3 years follow-up of a complete maxillary rehabilitation by subperiosteal implants in a young patient after an endosseous implant treatment failure.

Additively Custom-made 3D Printed Subperiosteal Implants for the rehabilitation of the Severely Atrophic Maxilla (a case report)

Mahnaz Arshad, D.D.S.[a] , Nourin Khoramshahi, D.D.S.[b] , Gholamreza Shirani, D.D.S., MD[c].

a Associate Professor, Department of Prosthodontics, School of Dentistry, International Campus, Tehran University of Medical Sciences, Tehran, Iran.

b D.D.S., School of Dentistry, International Campus, Tehran University of Medical Sciences, Tehran, Iran.

c Associate Professor, Department of Oral and Maxillofacial Surgery, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran

Corresponding Author:

Nourin Khoramshahi, D.D.S.

School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran

Address: Farhikhtegan Tower, Dr. Khoramshahi St., Kuhak Blvd, Tehran, Iran

Tel: +989102018828

Fax: +982146147212

Email: khrmshh@gmail.com

ORCID:

Mahnaz Arshad: 0000-0002-6278-6278

Nourin Khoramshahi: 0000-0002-6547-0877

Gholamreza Shirani: 0000-0002-6229-1320

All authors declare that there was no competing interest. The authors have no relevant financial or non-financial interests to disclose. The authors did not receive support from any organization for the submitted work. The patient has signed informed consent before each treatment procedure.

the journal if the journal publishes such work. Also, we hereby declare that non of the authors listed on the manuscript are employed by a government agency that has a primary function other than research and/or education and non of the authors are submitting this manuscript as an official representative or on behalf of the government. Additional data may be translated from persian and presented by the correspond author upon reasonable request.

Abstract word count: 49

Manuscript word count: 1537

Number of figures: 11

Key Clinical Message

Subperiosteal implants might be the future first-line treatment in patients with compromised alveolar ridges, although the use of proper techniques and pre-surgical imaging is required to ensure treatment success.

Abstract

In the past decade, on account of computer-aided prosthetic manufacturing techniques, subperiosteal implants were introduced as a safe option for patients with compromised alveolar ridges. We present 3 years follow-up of a complete maxillary rehabilitation by subperiosteal implants in a young patient after an endosseous implant treatment failure.

Keywords: Subperiosteal Dental Implantation, Alveolar Bone Loss, Bone Resorption, Endosseous Dental Implantation, Aggressive Periodontitis

Introduction

Dental endosseous implants are a favorable replacement for teeth in many cases. They offer a high success rate and predictable results. Some studies report that endosseous dental implants' success rate might rise to 89-99% (1). However, endosseous implants require a certain amount of bone quantity and quality to succeed, and their ideal requirements are not always available. In complicated cases where the alveolar bone is resorbed or compromised, the endosseous implantation procedure becomes challenging (2). Several strategies have been suggested aiming to induce bone regeneration. However, each method comes with many additional risks and complications. Bone grafts are the most adopted strategy to replace the resorbed alveolar bone. However, this treatment has many downsides, such as its complexity, long healing period, increased risk of complications, patient discomfort in extra-oral grafts, and limited bone supply in intra-oral grafts (3, 4).

Subperiosteal implants (S.P.I.s) were first introduced in the 1940s but were soon eliminated due to prevalent complications. The first models of subperiosteal implants were custom-made cobalt-chrome or titanium implants placed below the periosteum and held the prosthesis in place. These implants lacked adequate fitting and often caused peri-implantitis by implant movements (1, 5).

In the past decade, the concept of sub-periosteal implants has reemerged with the evolving digital technologies used in dental prostheses fabrications. Using additive manufacturing technology in S.P.I. fabrication has led to a better fitting and, therefore, a high level of bone to implant contact, which reduced implant failures dramatically (2, 5).

In this article, we present a case of S.P.I. in the maxillary after the failure of endosseous implant-supported prostheses. So a unique subperiosteal implant with abutments connected to the body of S.P.I. was designed.

Case report

In 2018 a maxillary edentulous 25-yrs-old male patient was referred to the prosthodontic department of Tehran University of Medical Sciences. His chief complaint was extreme dissatisfaction with appearance, mastication, and speech. A detailed medical, dental and social history was obtained. The medical history and general physical condition were unremarkable. Dental history showed that the patient lost his teeth six years ago because of aggressive periodontitis and received dental rehabilitation by implant-supported full mouth prosthesis, but, after five years, all maxillary implants failed (Figures 1a, b and c). Therefore, he requested full mouth dental replacement.

The clinical and radiographic examination revealed that the previous implant failure had caused severe alveolar resorption, and the patient lost a large amount of bone volume (Figure 2). Thus, placing endosseous implants again was not possible.

Bone graft surgery requires a prolonged healing period added to the waiting period in the implant treatments. The patient was young, and this delay might affect his social and psychological health. Considering the risk of complications followed by extensive bone graft and the unpredictable prognosis of this strategy, we decided to perform S.P.I. reconstruction in the maxilla (Figure 2).

To achieve the best function and aesthetic possible, first, we obtained the primary impressions from both jaws using a prefabricated tray and irreversible hydrocolloid material (Alginate, Zhermack, Badia Polesine (R.O.), Italy). a special tray was fabricated by auto-polymerizing acrylic resin and border molded using a green modeling plastic impression compound (Kerr Corp., Bioggio, Switzerland) to achieve a more accurate final impression. The final impression was obtained using zinc oxide eugenol paste (Luralite, Kerr, U.S.A.). A maxillary record base and a wax rim were fabricated. Jaws relationship was registered then the Maxillary cast was mounted using an arbitrary face bow (Dentatus, Dentatus Ltd., NY) on a semi-adjustable articulator (Dentatus A.R.H., Dentatus Ltd., NY). The mandibular cast was connected to the maxilla using a centric relation record. Anterior tooth set-up (Vivotac/Orthotak, Ivoclar Vivadent, Schaan, Liechtenstein) was accomplished on the mounted casts, and a diagnostic tooth set-up was performed and tried in. The acrylic teeth were poured with barium sulfate (Foshan Xinmei Chemical, Guangdong, China) containing acrylic resin. This made the teeth opaque so that the occlusal plane and longitudinal axis of teeth could be detected in the 3D-C.T. scan to determine the proper location of abutments on S.P.I., The center of the posterior teeth and the cingulum of anterior teeth to the crest of the maxillary ridge were perforated with fissure tungsten laboratory bur to make the lucency in the C.T. scan to determine the longitudinal axis of final implant abutments (Figures 3 a, b, c, d).

With the consult of the prosthodontist, the engineer designed the S.P.I. Therefore a 3D model based on the patient's C.T. was generated to assess the optimum S.P.I. design and positioning. After carefully planning the implants' placement, we fabricated the S.P.I. using the Additive Manufacturing technique by Titanium alloy grade 23 (Ti6AL4V-ELI, Bonash Company, Iran) (Figure 4). The critical point of this design was that because the abutment was connected to the body and it was impossible to change the abutment angles, the abutment angles were designed very precisely using 3D C.T. using a radiographic stent. After manufacturing the S.P.I., it was screwed into a printed skull, and the prosthodontist checked the interocclusal clearance and abutments angles and positions (Figure 4). Then it was scanned, and STL data was sent to the laboratory. Then S.P.I. was sent to the cleaning room and sterilized with an autoclave. The patient underwent surgery with general anesthesia to place the S.P.I (Figures 5 a and b).

After two weeks, a temporary implant-supported bridge was delivered to the patient (Figure 6). They were cemented with temporary cement (Temp bond, Kerr, U.S.A.) (Figure 7a and b). Minor dehiscence was found in the left premolar area of the maxilla (Figure 8a and b). However, this dehiscence did not extend in the following sessions. Three months later, the three-part full ceramic CAD/CAM bridges with BL4 shade for the maxilla were fabricated based on the scanned data (Figure 9). Crowns were tried in the mouth, and the fit of frames was checked. The teeth were adjusted to achieve group function occlusion. Implant-supported crowns were cemented with temporary cement (TEMP Bond, Kerr, U.S.A.) (Figure 10). We scheduled follow-up sessions post-delivery, and the patient was instructed to a careful oral hygiene routine consisting of waterjet, teeth brushing, and super floss. The patient was satisfied with the results during the three-year follow-up (Figure 11).

Discussion

Since the 1980s, dental endosseous implants have become one of the most common replacements for teeth

(1). However, the need for adequate bone quality and quantity is not always met. On the other hand, reports show that bone resorption continues post-implantation, which endangers the implant condition, and represents a significant challenge for future treatment. Dental rehabilitation of a resorbed alveolar ridge, regardless of the cause, requires a complicated course of treatment and is challenging. Bone grafts are the most common bone replacement in such cases. However, bone grafts need a long healing period and have unpredictable results (3, 6). Also, they might cause significant complications. For instance, a study reports that neural complications related to an intra-oral bone graft strategy may rise to 50% (7).

Recent advancements in dental prostheses have allowed us to revisit older treatments with reduced complication risk. The S.P.I.s are considered to be a replacement for different types of bone grafting and other strategies applied on a compromised ridge. With the latest accomplishments in the field of prostheses manufacturing, we have overcome most of the previous complications (2, 5).

In this report, we explained the steps and strategies applied to fabricate and deliver an S.P.I. for our patient. The patient had lost his teeth at quite a young age due to aggressive periodontitis and received dental endosseous implants as a replacement. Unfortunately, after five years, the prosthesis and implants were explanted, leaving him in need of another treatment course. This time, the maxillary alveolar ridge was severely resorbed, and he was no longer a candidate for endosseous implants. Therefore, we decided to use an S.P.I. for full mouth rehabilitation. Our 3years follow-up shows that the S.P.I. is in excellent condition, and the patient is satisfied with the results.

The results of a retrospective study on 70 patients with S.P.I.s show that after 2years of follow-up, the survival rate of S.P.I.s was approximately 96%. In the study, the authors report that only three of the S.P.I.s failed due to untreatable recurrent infection. (8)

In a more recent case series study, the survival rate of 10 S.P.I.s in partially edentulous patients was 100% after 12 months of follow-up. However, one S.P.I. had a minor immediate post-operative complication managed successfully by antibiotics and pain-relievers. The authors believe that the accurate fit of the S.P.I.s was the main reason for the low incidence of complications resulting in a high survival rate. (9)

The S.P.I.s have reemerged, especially during the last decade, and reports of successful S.P.I. dental rehabilitations are increasing thanks to the new manufacturing techniques. (2) Nevertheless, underestimating the importance of different procedure steps may cause many complications and may eventually lead to implant failure. For instance, using a radiographic stent based on a provisional dental setting helps determine the perfect design and angulation for the attachments.

Authorship

M.A.: involved in the study conception and design, material preparation, prosthodontic treatment of the patient, and revised the manuscript; N.K.: involved in material preparation, drafted and revised the manuscript; G.S.: involved in the study conception and design, material preparation, and surgical treatment of the patient.

Acknowledgments

The authors thank BONASH (Tehran, Iran) for manufacturing the subperiosteal implant.

Conflict of interest

All the authors of this report wish to disclose that there are no financial or other conflicts of interest that might have biased the scientific information in this article.

Patient consent

The patient has signed an informed written consent form for publishing this report. The consent form was translated to persian based on the journal's patient consent policies.

Abbreviation

S.P.I: Subperiosteal implants

C.T.: Computed tomography

CAD/CAM: Computer-Aided Design / Computer-Aided Manufacturing

References

1. W Nicholson J. Titanium alloys for dental implants: A review. Prosthesis. 2020;2(2):100-16.

2. Mommaerts M. Evolutionary steps in the design and biofunctionalization of the additively manufactured sub-periosteal jaw implant 'AMSJI'for the maxilla. International Journal of Oral and Maxillofacial Surgery. 2019;48(1):108-14.

3. Chiapasco M, Tommasato G, Palombo D, Scarnò D, Zaniboni M, Del Fabbro M. Dental implants placed in severely atrophic jaws reconstructed with autogenous calvarium, bovine bone mineral, and collagen membranes: A 3-to 19-year retrospective follow-up study. Clinical Oral Implants Research. 2018;29(7):725-40.

4. Moy PK, Aghaloo T. Risk factors in bone augmentation procedures. Periodontology 2000. 2019;81(1):76-90.

5. Garrido-Martinez P, Quispe-Lopez N, Montesdeoca-Garcia N, Esparza-Gomez G, Cebrian-Carretero J-L. Maxillary reconstruction with subperiosteal implants in a cancer patient: A one-year follow-up. Journal of Clinical and Experimental Dentistry. 2022;14(3):e293.

6. Um I-W, Ku J-K, Kim Y-M, Yun P-Y, Chang N-H, Kim Y-K, et al. Allogeneic demineralized dentin matrix graft for guided bone regeneration in dental implants. Applied Sciences. 2020;10(13):4661.

7. Chiapasco M, Casentini P, Zaniboni M. Bone augmentation procedures in implant dentistry. International Journal of Oral & Maxillofacial Implants. 2009;24.

8. Cerea M, Dolcini GA. Custom-made direct metal laser sintering titanium subperiosteal implants: A retrospective clinical study on 70 patients. BioMed research international. 2018;2018.

9. Mangano C, Bianchi A, Mangano FG, Dana J, Colombo M, Solop I, et al. Custom-made 3D printed subperiosteal titanium implants for the prosthetic restoration of the atrophic posterior mandible of elderly patients: a case series. 3D Printing in Medicine. 2020;6(1):1-14.

Figures

Figure 1. Different views of patient 1 year after the initial implants failure. a: Frontal view, b: Occlusal view, c: Lateral view.

Figure 2. Panoramic radiography taken 1 year after the initial implants failure.

Figure 3. Different views of subperiosteal implants' 3D model design.

Figure 4. The fabricated S.P.I model screwed to a printed skull to evaluate it.

Figure 5. After final confirmation of the implant, an oral surgery was performed to place the implant.

Figure 6.Temporary prosthetic design based on 3D printed skull model.

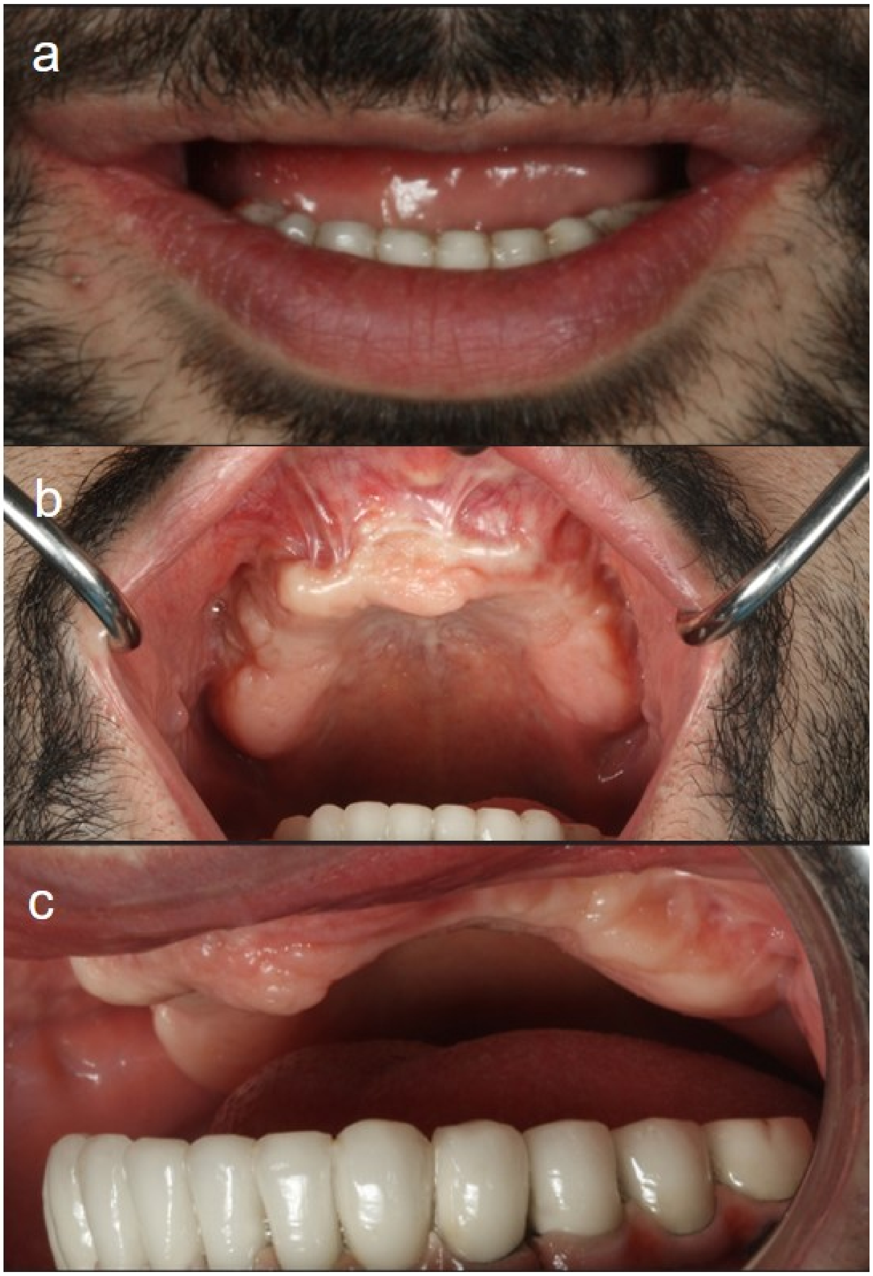
Figure 7. The temporary prosthetic cemented in place.

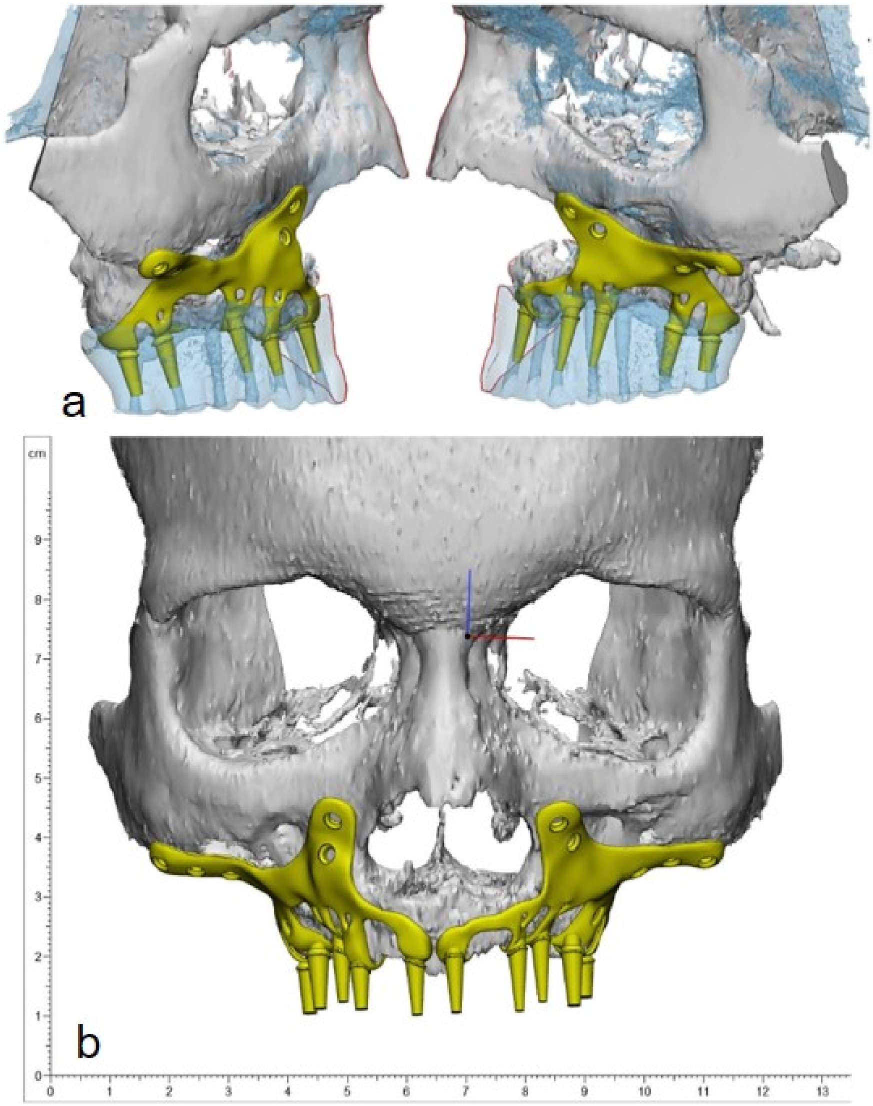
Figure 8. A minor dehisence occurred in the left premolar area but did not extend over time.

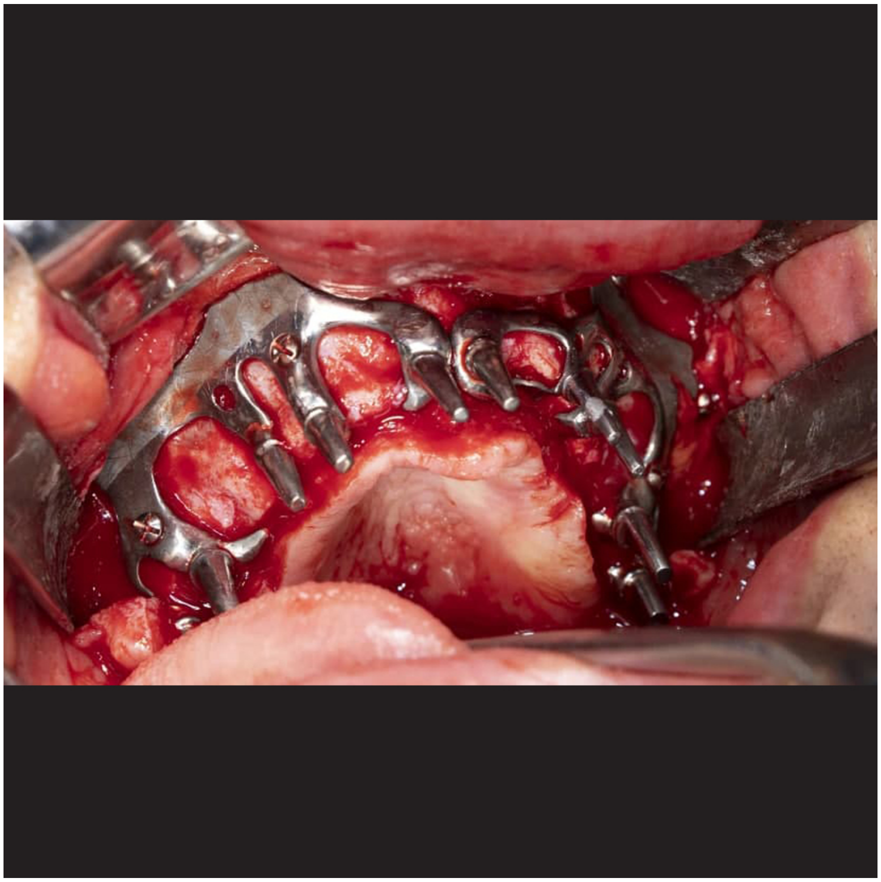
Figure 9. The prosthetic design.

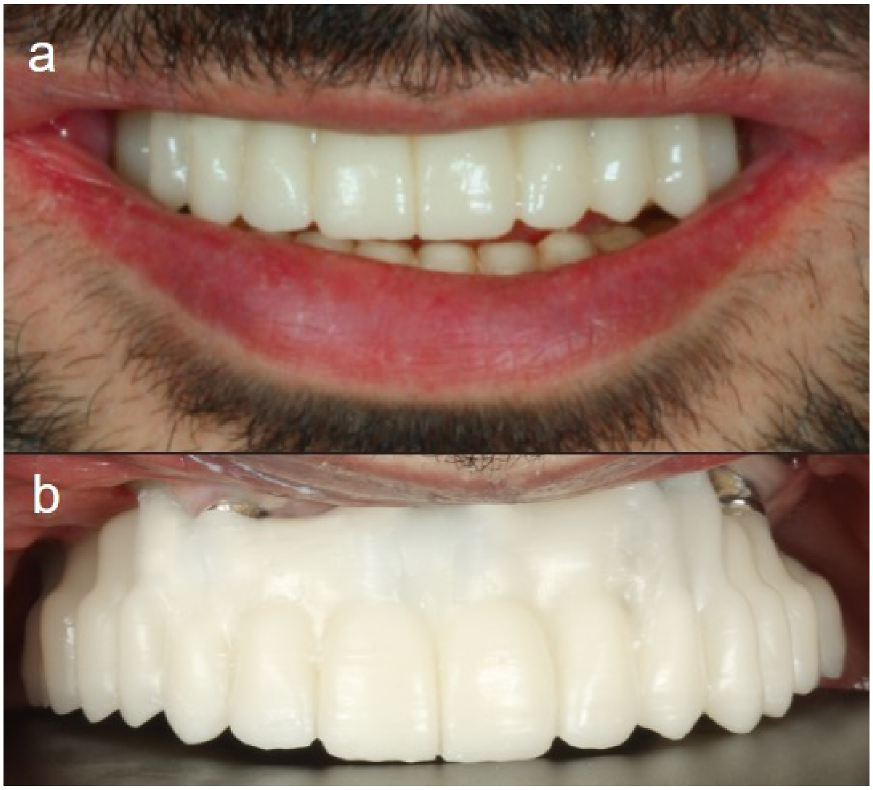
Figure 10. Final prosthetic delivary.

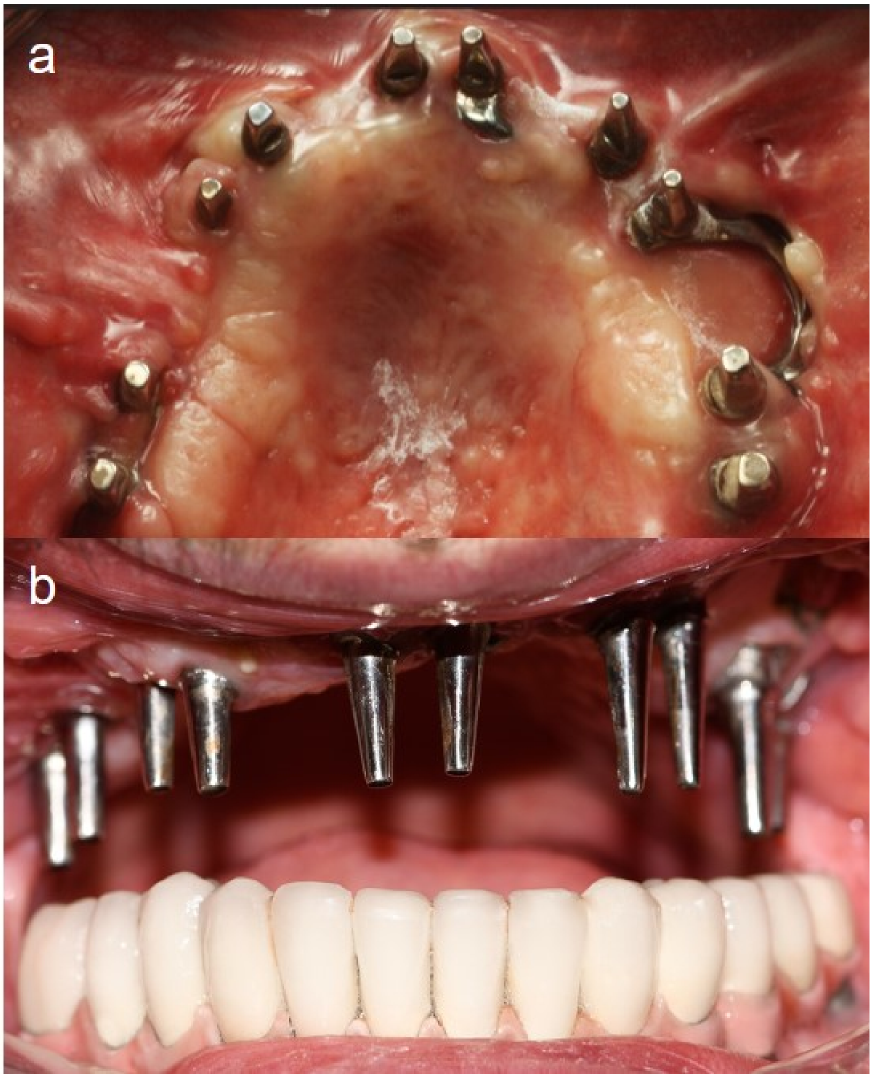
Figure 11. Panoramic radiography showing implant status after 3 years.


a
b
c


a
b
cm
9
8
7
6
5
4
3
2
1
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13




a
b


a
b


Vatech
R