J Stomatol Oral Maxillofac Surg 121 (2020) 25–29

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Original Article

Horizontal augmentation of the maxillary alveolar ridge to change the prosthetic profile: Clinical and radiological results of a retrospective study

A.J. Arcas-Sanabre [a], J. Gutierrez-Santamaria [a], J. López-López [b,c], R. Ayuso-Montero [a,b,c,d,e,*], E. Velasco-Ortega [e]

[a] University Hospital Quirón Dexeus, Barcelona, Spain
[b] Department of Odontoestomatology, Faculty of Medicine and Health Sciences (Dentistry), University of Barcelona, Barcelona, Spain
[c] Oral Health and Masticatory System Group, Bellvitge Biomedical Research Institute (IDIBELL), L'Hospitalet de Llobregat, Barcelona, Spain
[d] Faculty of Dentistry, University of Barcelona, Barcelona, Spain
[e] Faculty of Dentistry, University of Seville, Seville, Spain

ARTICLE INFO

Article history:
Received 1st July 2019
Accepted 5 August 2019

Keywords:
All-on-4
All-on-6
Atrophic maxilla
Prosthetic profile
Ridge augmentation
Zygomatic implants

ABSTRACT

Background: In this retrospective study, we aimed to analyze the clinical and radiological results of compensating the long-term deficiencies in hard and soft tissues of edentulous patients by placing dental implants and performing a horizontal ridge augmentation.
Material and methods: We treated patients with edentulous maxillaries (Cawood–Howell type III or IV) by combining 4 implants, or 6 implants, or using zygomatic and conventional anterior implants as appropriate. Simultaneously, horizontal ridge augmentation was performed by combining autologous bone with Bio-Oss and membranes.
Results: A total of 14 zygomatic and 80 standard implants were used for the rehabilitations in 16 edentulous patients. The success rates were 93.75% and 85.71% for the standard and zygomatic implants, respectively. Also, respective gains of 5.79 mm and 3.25 mm were obtained at the levels of the midsagittal line and canines, with respective resorption rates of 10% and 8.6% after 20 months.
Conclusion: The millimeters gained by performing a horizontal augmentation optimizes the relation between the implant position and the prosthetic profile. This allows the different prostheses to be selected and for rehabilitation to be optimized. In this way, mucosal coverage can be avoided and fixed prosthetic design can be enhanced.

1. Introduction

Rehabilitation of atrophic maxillary bone in long-term edentulous patients has always been a major challenge for oral and maxillofacial surgeons [1]. The centripetal atrophy occasioned by teeth loss causes bone crests of class IV–VI on the Cawood–Howell Classification [2]. This bone loss is accompanied by soft tissue deficiency, causing a diminution of the oral vestibule depth and a reduction in the quality and quantity of connective tissue for the alveolar mucosa [3]. Although different approaches have been used to treat these patients, overdentures and fixed rehabilitations provide good function and oral health-related quality of life. However, patient perspectives are important and should also be evaluated [4].

Implant procedures that use graftless approaches have been developed to obtain fixed prosthetic rehabilitation. These include using four implants [5–7], six implants [8], or zygomatic implants with two or four anterior implants [9–12], to take advantage of any available bone. Each of these approaches has shown a high implant survival rate after 10 years. The main problem with fixed prosthetic rehabilitation performed using these approaches concerns the alveolar ridge reconstruction. Indeed, prosthetic profiles can result in suboptimal transition between the implant and the tooth position (Fig. 1), which may cause hygienic, aesthetic, and functional difficulties [13,14].

Therefore, supplementary techniques have been developed to augment bone volume, including onlay grafting, sinus or nasal

* Corresponding author at: Department of Odontoestomatology, Faculty of Medicine and Health Sciences (Dentistry), University of Barcelona, C/Feixa Llarga s/n, Pavelló de Govern, 2a planta, L'Hospitalet de Llobregat, 08907 Barcelona, Spain.
E-mail address: raulayuso@ub.edu (R. Ayuso-Montero).

https://doi.org/10.1016/j.jormas.2019.08.001
2468-7855/

Fig. 1. Transition between the implant position and the prosthetic profile.

grafting, interposition grafting, ridge splitting, and distraction osteogenesis [15,16]. These autologous grafts are considered the gold standard techniques when reconstruction is performed in cases with severe atrophy, but they have limited availability and increase patient morbidity [17–19]. Moreover, the inability to predict the percentage of graft resorption could lead to a lack of bone quality and volume [20]. Another procedure that permits the placement of dental implants in an atrophic maxilla is the Le Fort I osteotomy followed by removal of the mucous membrane of the sinus floor, and obturation of the maxillary sinus floor by autologous bone grafts [21].

To minimize the risks associated with obtaining autologous bone, the use of xenogenic or synthetic matrixes has been proposed [20]. Further support could be provided by combining augmentation of the horizontal crest of the maxillary bone through membranes and xenogenic bone with implants placement. This might involve four implants, six implants, or zygomatic plus axial implants. Together, these might make it possible to project the oral vestibule by several millimeters to optimize the implant–crown transition, improving hygienic, aesthetic, and functional outcomes.

The aim of this retrospective study is to analyze clinical and radiological results of a case series using the combination of these techniques.

2. Materials and methods

2.1. Study design

This was a retrospective study of a single cohort of patients treated at University Hospital Quirón Dexeus, Barcelona, Spain. Data between September 2013 and January 2016 were analyzed. We included patients who were older than 18 years, were totally edentulous in the maxilla, had an alveolar ridge of Cawood–Howell type III or IV, and underwent treatment with the expectation of receiving fixed prosthodontics.

The study was conducted in accordance with the principles of the Helsinki Declaration of 1964 for biomedical research involving human subjects, as amended in 2008. All patients were duly informed and gave written consent.

2.2. Treatment planning

An experienced prosthodontist planned the ideal upper teeth position required for a satisfactory esthetic and functional maxillary profile. The prosthetic planning was replicated to obtain a surgical guide and a fixed temporary restoration.

2.3. Surgical procedures

A team of experienced maxillofacial surgeons performed all surgical procedures. This involved augmentation of the alveolar ridge by combining xenogenic bone (Bio-Oss®, Geistlich AG, Wolhusen, Switzerland) and membrane (30 × 40 mm, Bio-Gide®, Geistlich AG, Wolhusen, Switzerland) with dental implants (zygomatic plus anterior implant, all-on-4® implant, or all-on-6® implant methods, depending on bone availability). All zygomatic implants were Brånemark System Zygoma (Nobel Biocare®, Kloten, Switzerland) and the anterior implants, the implants used in the all-on-4®, and the implants used in the all-on-6® were Brånemark System Mk IV (Nobel Biocare®, Kloten, Switzerland). To ensure the stability of the platform for dental implants in remaining bone, vertical reduction of the ridge was performed before implant placement. The amount of vertical bone reduction was 1 to 3 mm and was determined during the surgery using the surgical guide. The optimal transition between the implant position and the prosthetic profile was considered in this vertical reduction. After implantation, the collagenous membrane was adapted to fit horizontally in the premaxillary region and was attached to the bone by pins in the superior paranasal region, nasal spine, and superolateral region at the level of the canines. Bio-Oss® was mixed with autologous bone chips, collected during vertical reduction, in a 1:1 ratio. The mixture was then used to fill and tension the membrane until it reached the vestibular volume (Fig. 2). Finally, the membrane was attached to the alveolar ridge and the surrounding gingiva was sutured.

2.4. Prosthodontic procedures

In the surgical session, multi-unit abutments (Nobel Biocare®, Kloten, Switzerland) were placed in every implant to parallelize the emergences. A screw-retained temporary fixed dental prosthesis was splinted to the temporary abutments anchored to the multi-unit abutments. Four months later, the temporary rehabilitation was removed, and conventional procedures were followed to fabricate screw-retained prostheses made of porcelain fused to metal (Fig. 3).

2.5. Data collection and analysis

The implant survival, postsurgical complication, and prosthodontic complication rates were recorded. The maxillary width was measured in three stages by comparison with controls: presurgical, 4 months postsurgical, and after 20 months postsurgical, using computed tomography scans. Measurements were taken in a blinded manner by an external observer using the NobelClinician©

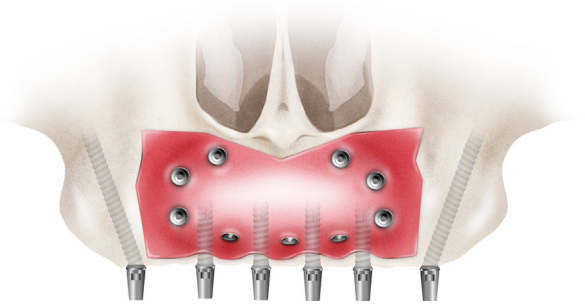

Fig. 2. Membrane position in the inter-canine region after implant placement.

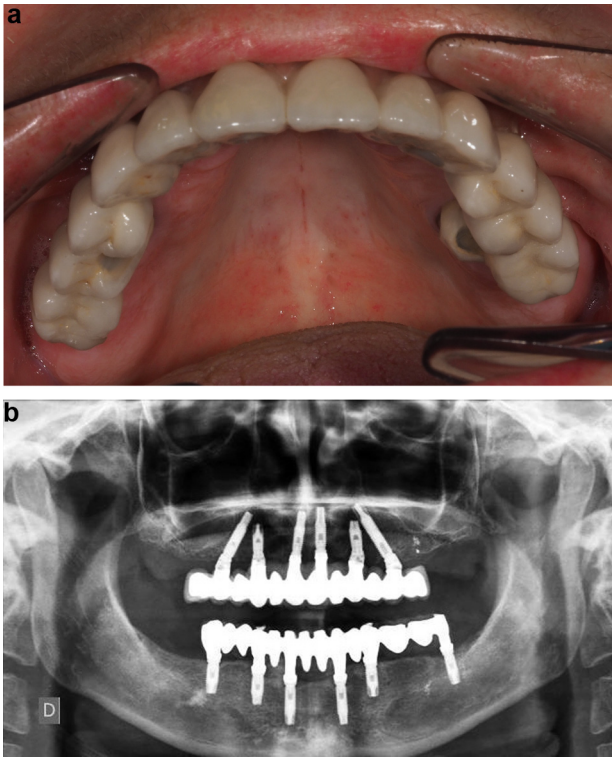

Fig. 3. Screw-retained final rehabilitation on the maxillary implants: a: clinical view; b: panoramic X-ray.

software (Nobel Biocare®, Kloten, Switzerland) in orthoradial slices at the midsagittal line and the paramedial zone at the levels of the right and left canines (Fig. 4). Data analysis was performed using the StatCrunch© software (Pearson, NJ, United States), and results are presented as means ± standard deviations or as numbers (percentage), unless otherwise stated.

Table 1
Number and type of implants used on each patient.

	Patient numbers per combination	Implant type	
		Standard Per person (total)	Zygomatic Per person (total)
Implant combinations	1	4 (all-on-4®)	0
	8	6 (48) (all-on-6®)	0
	5	4 (20)	2 (10)
	1	3	3
	1	5	1
Total	16	80	14

3. Results

Among 19 patients who met the inclusion criteria, only 16 were included because 3 did not complete the observation period. These comprised 12 females and 4 males aged 59.31 ± 10.67 years. In total, 94 implants were used in the 16 patients, of which 14 were zygomatic and 80 were standard. The different combinations of implants and techniques are described in Table 1. The standard implants inserted distally to the canines and the zygomatic implants were used as a posterior anchorage, then sixty one of the 80 standard implants and none of the zygomatic implants were inserted on the grafted area.

Five of the standard implants and two of the zygomatic implants failed during the four-month temporary restoration period, giving success rates of 93.75% and 85.71%, respectively.

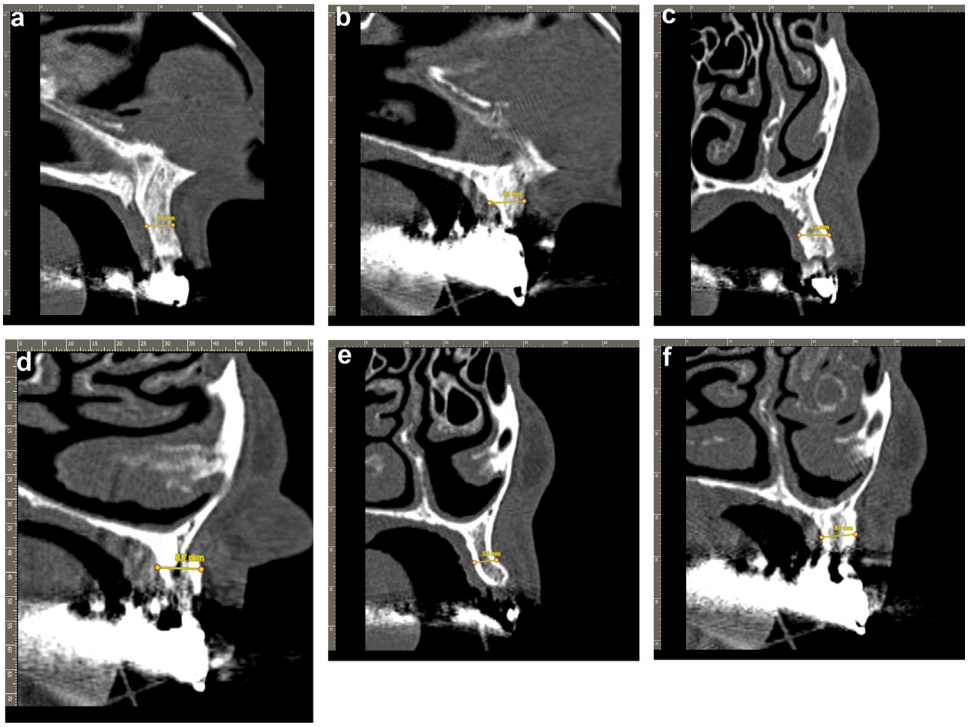

Fig. 4. CBCT images of measurements taken on orthoradial slices at the midsagittal line and the paramedial zone at the levels of the right and left canines: a: measurement of orthoradial slice before surgery at the level of the right canine; b: measurement 20 months after surgery at the same level; c: measurement before surgery in the midsagittal line; d: measurement 20 months after surgery at the same level; e: measurement before surgery at the level of the left canine; f: measurement 20 months after surgery at the same level.

Table 2
Measurements of the augmentation.

	Presurgical		Postsurgical		20 months	
	Mean ± SD	(95% CI)	Mean ± SD	(95% CI)	Mean ± SD	(95% CI)
Midline (mm)	3.13 ± 1.24	2.52 ± 3.74	8.94 ± 1.88	8.02 ± 9.86	8.01 ± 0.55	7.74 ± 8.28
Canines (mm)	2.42 ± 0.98	2.09 ± 2.75	5.67 ± 1.59	5.12 ± 6.22	5.18 ± 0.32	5.06 ± 5.30

CI: confidence interval.

Four (two standard and two zygomatic) of the seven failed implants were replaced because they were considered essential for the final restoration. No other implant failed during the 20-month follow-up period. However, one patient needed an extra appointment for surgical complications (swelling), but this was considered normal after assessment, and no signs of infection were observed in the failed implants. Another patient suffered from prosthetic complications with the final restoration (chipping), which was satisfactorily resolved by removing the ceramic and making a new porcelain coating.

The graft measurements obtained by computed tomography are shown in Table 2. An average postsurgical augmentation of 217% was obtained at the midsagittal level (5.79 ± 1.35 mm; 95% CI: 5.13–6.45) compared with 134% at the canines (3.25 ± 1.22 mm; 95% confidence interval [95% CI]: 2.83–3.67). This result provided sufficient anatomical support for the upper lip while avoiding interference with the prosthetic profile. Twenty months after restoration, the total width loss of bone and graft was 10% in the midsagittal zone (0.93 ± 0.11 mm; 95% CI: 0.88–0.98) and 8.6% at the level of the canines (0.49 ± 0.08 mm; 95% CI: 0.4–0.52). These values have been obtained by the differences between the postsurgical and presurgical measurements, and the 20 months and postsurgical measurements explained in Table 2.

4. Discussion

The aim of combining the augmentation of the horizontal crest of the maxillary bone with implant placement is to improve the aesthetic and functional outcomes for the rehabilitation of severe maxillary atrophy. The technique described in this study does not increase morbidity and is highly cost-effective. Moreover, consistent with previous results, it can be performed under local anesthesia and provides immediate results with a low rate of graft resorption [22]. This procedure can be performed to optimize the transition between implant position and prosthetic profile, which is a major ongoing challenge of graftless approaches.

The criteria for deciding prosthesis type according to Avrampou et al. rely on the mucosal coverage and the prosthetic profile [1]. Ultimately, the optimal position of the prosthetic teeth and the labial support determine the prosthetic design needed to provide good facial esthetics. When correcting Cawood–Howell types III and IV, a hybrid design is recommend to achieve optimal rehabilitation with mucosal coverage ranging from 0 to 5 mm, with a removable overdenture used when this measure exceeds 5 mm. Nevertheless, mucosal coverage is only defined as a vertical measure, whereas labial support can be provided by horizontal augmentation. Vertical reduction performed before implant placement reduces the angle between the buccal end of the implant platform and the cervical point of the prosthetic profile, but the space gained by horizontal augmentation avoids the need for mucosal coverage. These modifications benefit patients and professionals who aim for fixed prostheses, changing the parameters of resorbed maxillary bone and allowing for the selection of a wider range of prostheses. Patients with Cawood–Howell types III or IV initially scheduled to receive hybrid prosthetics can receive crowns, whereas patients initially scheduled to receive overdentures can receive hybrid designs.

The success rate associated with standard implants (93.75%) was slightly lower in this study compared with that obtained by other authors (96%–96.9%) in a similar patient cohort evaluated retrospectively over 5 years [23]. The success rate of zygomatic implants (85.71%), however, was approximately 10% lower than that reported in a systematic review (95.1%) covering a period of 12 years [11]. Although the observation period was significantly shorter in our study, all failures in the review occurred within 6 months of surgery. The lack of osseointegration of failed implants was attributed to the amount of remaining available bone and the immediate loading with a fixed temporary restoration.

The horizontal augmentation measurements indicated a total loss of bone and graft width ranging from 8.6% at the canines to 10% at the midline (Table 2). This resorption was slightly less than that reported by other authors using the same mixture of xenogenic and autogenous bone for similar defects [22]. In a prospective study, residual ridges measuring less than 4 mm were treated regardless of the oral region, and outcomes were evaluated for a 1-year follow-up period. Other research for sinus augmentation has shown a resorption rate of 14% over 6 months when using the same mixture [24]. Of note, the evaluation period of the present study was significantly greater than for either of these studies. However, this evaluation period is a weakness of this study in order to detect late perimplantitis or in terms of implant survival rate.

5. Conclusions

The transition between the implant position and the prosthetic profile can be effectively modified by combining implants placement with horizontal augmentation procedures. The increase in postsurgical augmentation in this study (in millimeters) ranged from 134% to 217%, with only 10% resorption observed after 20 months. These promising outcomes indicate that this approach can help avoid mucosal coverage and enhance fixed prosthetic designs.

Disclosure of interest

The authors declare that they have no competing interest.

Acknowledgments

We would like to thank Dr. Jan Martínez-Lozano for his help in the translation of the manuscript and the statistical analysis.

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