Chapter

A Review of Current Concepts in Full Arch Rehabilitation with Dental Implants

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Abstract

Various causes can be responsible for tooth loss. In general, caries, periodontal disease, facial trauma, pathology of the jaws, among other causes, could lead to the loss of a tooth or a group of teeth. As a consequence, the stimuli that participate in bone maintenance are compromised and bone reduction occurs gradually, making it difficult to use conventional prostheses. Fortunately, technological advances applied to dental implantology have allowed us to perform full-arch prosthetic treatments, managing to rehabilitate the form, function, esthetics and lost self-esteem in patients with severe atrophy of the jaws. The objective of this chapter is to describe the key and current aspects in full-arch rehabilitation with dental implants.

Keywords: dental implants, buttress implant, hybrid prosthesis, full arch, all on X, zygomatic implants

1. Introduction

Edentulism is a state of oral health that consists of the loss of teeth. Although the causes of tooth loss are diverse, dental cavity and periodontal disease are the main causes. Despite the decrease in edentulism in developed countries, edentulism continues to have a high prevalence affecting multiple functions such as chewing, nutrition, speech, self-esteem and quality of life [1].

After tooth loss, the physiological stimuli that give mechanical and cellular maintenance to the alveolar bone disappear. As a consequence, there is a reduction in the quantity and quality of bone, which we define as bone atrophy. The International Journal of Oral & Maxillofacial Implants defines alveolar atrophy as "decrease in the volume of the alveolar process occurring after tooth loss, drecased fuction and/or localized overloading from an improperly fitting removable partial or complete denture" [2].

Conventional full arch rehabilitation treatments achieved stability, support and retention at the expense of remaining teeth or residual bone anatomy. However, when a patient has edentulism and bone atrophy, conventional rehabilitative treatment does not meet the treatment goals, expectations, and comfort for the patient.

Dental implants are biocompatible alloplastic devices that are inserted into a residual bone ridge. The use of osseointegrated endosteal implants was introduced in

North America in 1982 thanks to the research of Dr. Branemar. His results established the guidelines for contemporary implantology [3].

To replace missing teeth there are different prosthodontic options. Which include implant-supported crowns (ISCs), implant-supported fixed dental prostheses (IFDPs), implant-supported removable dental prostheses (IRDPs), tooth-supported fixed dental prostheses (TFDPs), and removable partial dentures (RPDs). In patients with several missing teeth, implant-supported fixed dental prostheses (IFDPs) have shown excellent results in the short and medium term, positively impacting quality of life [4].

The objective of this chapter was to describe the key and current aspects in full-arch rehabilitation with dental implants. The purpose is to guide professionals in the diagnosis and rehabilitation treatment of the full arch with dental implants in the patient with edentulism.

2. Diagnosis of the patient with bone atrophy, selection of the patient

As mentioned, dental extraction induces a series of physiological changes in the hard and soft tissue of the dental socket. These local alterations arise as a natural healing process that aims to achieve a secondary closure of the wound and the dental socket. The healing phases of an alveolus include an inflammatory phase, a proliferation phase, and a remodeling phase. After multiple tooth extractions with or without the use of dentures, people may suffer from extensive vertical and horizontal reduction in their alveolar bone process. A reduction of up to 50% of the original bone table can be expected, being greater in the buccal aspect than in its lingual/palatal counterpart [5]. This process of bone resorption continues and determines the morphological configuration of the alveolar process and the severity of the bone atrophy of the jaws. Occasionally, bone resorption is so severe that the alveolar process may be non-existent, compromising important anatomical structures such as the maxillary sinus, the piriformis notch, the nasopalatine nerve, the inferior alveolar nerve, among others (**Figure 1**).

Currently there are multiple classifications that describe alveolar bone atrophy. The two most used are the Seibert classification and the Cawood and howell classification. The Seibert's nomenclature divides alveolar bone loss into three types: Class 1: Loss of vestibule/lingual tissue with normal bone crest height, Class 2: Loss of apical/coronal tissue with normal vestibule/lingual dimension, Class 3: Loss combined horizontal and vertical bone [6].

The Cawood and Howell classification evaluates the post-extraction socket and the edentulous crest for a subsequent restoration treatment, it is divided as follows: Class I: toothed, Class II: post-extraction, Class III: convex shaped process, with width and height adequate, Class IV: sharp edge with adequate height, insufficient width of alveolar process, Class V: flat shape with loss of alveolar process, Class VI: loss of basal bone [7].

Regardless of the degree and severity of bone atrophy, the patient's selection for full arch rehabilitation treatment with dental implants depends on his or her expectations. During the consultation, it is essential to carry out an adequate questioning and understand the reason for our patient's consultation. Esthetic, functional and personal needs. In general, when a patient requires a complete rehabilitative treatment, he has undergone multiple treatments throughout his life, his mentality towards treatment, although in most cases it is "philosophical", sometimes we could have demanding patients with "hysterical" mentality.

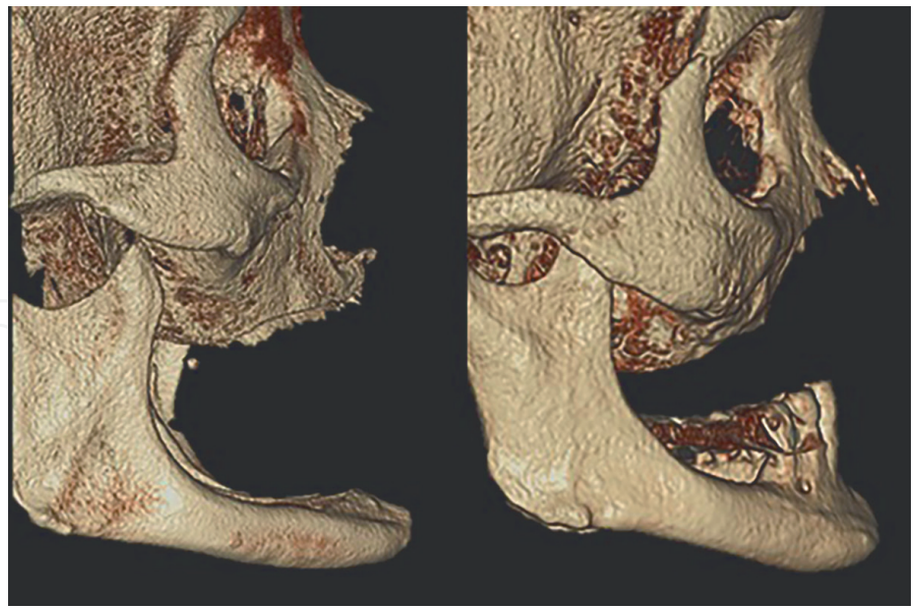

Figure 1.
Different degrees of bone atrophy. The first patient presents a mild/moderate maxillary atrophy, however, he presents a severe mandibular atrophy at the level of the inferior alveolar nerve. The second patient presented severe maxillary atrophy with loss of the premaxilla. The atrophy extends posteriorly to the floor of the maxillary sinus, making it impossible to place conventional implants. In the mandible it presents a mild/moderate atrophy in the posterior sector.

Understanding the attitude of patients and their expectations is important for the success of full arch rehabilitation and to offer the best rehabilitative treatment [8].

In general, indications for a full arch rehabilitative treatment with dental implants include:

- Complete edentulism of one or both jaws.
- Partial edentulism with poor periodontal and prosthetic prognosis for existing teeth.
- Failure or denial of fixed prosthetic treatment or conventional prosthodontics.
- Moderate and severe atrophy that does not achieve retention with the use of conventional prostheses [9].
- Xerostomy or hypersensitivity of the mucosa that prevents the use of conventional prostheses [10, 11].

There are few contraindications to dental implant treatment, most are relative and not absolute.

- Uncontrolled systemic disease: Systemic compromises such as cancer, radiotherapy, chemotherapy, autoimmune diseases, HIV, bisphosphonates and bone diseases could contraindicate treatment if the patient does not have a pharmacological control with adequate response to treatment. However, when these conditions are medically controlled and performed with established protocols, they can have a high success rate and are not an absolute contraindication to dental implant treatment [12–14].

- Alcoholics, drug addicts or patients with psychosis: these are patients who have no commitment and good control of treatment. This could lead to complications and a low success rate. Smoking patients may have a higher failure rate for dental implant treatment. However, it is not an absolute contraindication to treatment [15].

- Allergy to titanium: Although allergy to titanium is extremely low (0.6%), this can explain a failure of implants or previous treatments in an inexplicable way. Currently, zirconia implants have been manufactured that can satisfactorily solve this situation [16, 17].

- Pregnancy: Rehabilitation treatments with dental implants should be postponed during the gestation period. During treatment, advanced imaging studies are needed in addition to the pharmacological implications during and after surgery.

3. Therapeutic options: bone grafting versus buttress implant concept

There are different surgical techniques used in the rehabilitation of atrophic jaws that are divided into two large groups: Non-grafted versus Grafted treatments. Graft procedures include: bone regeneration with bone substitutes with or without the use of membranes, maxillary sinus lift and platelet-rich plasma [18, 19].

Procedures that do not use grafts, use skeletal anchors with long and conventional implants in the different anatomical points of the facial bones.

For both techniques there is a high success rate of 90–95% at 5 years with no statistically significant difference in implant survival [20].

Currently there are multiple classifications with diagnostic and therapeutic criteria in rehabilitation with dental implants. However, there is no classification that unites all implant alternatives with diagnostic, surgical and implant criteria.

The buttress implant concept is a classification that I have designed and is based on the bony buttresses of the face. These areas offer adequate quality and quantity of bone where the placement and functional load of osseointegrated implants is feasible.

The classification for the patient with jaws atrophy is divided into 6 zones: Zone I/maxillary alveolar buttress, Zone II/nasomaxillary buttress, Zone III/zygomatico-maxillary buttress, Zone IV/pterygomaxillary buttress, Zone V/mandibular alveolar buttress and Zone VI mandibular/basal buttress (**Figure 2**).

- Zone I/alveolar buttress: In the alveolar buttress of the maxilla we can anchor osseointegrated implants in the bone process. In this area we can place implants axially or tilted. Tilted implants with an angle between 17° and 45° perform as well as axial implants. Among our options, in this buttress we find conventional and short implants ≤8 mm, nasopalatine duct implant, tilted implants such as those described in the All on 4 techniques, and tuberosity implants [21].

- Zone II/nasomaxillary buttress: Although the term "Nasomaxillary implant" has not been defined in the Glossary of Oral and Maxillofacial Implants (GOMI) [22]. I define it as "Implant placement through the alveolar process and into the nasomaxillary buttress". Nasomaxillary implants can be used as an anchorage point in a location anterior to the prosthetic arch. With this, we achieve anterior stability and the reduction of work forces in posterior implants.

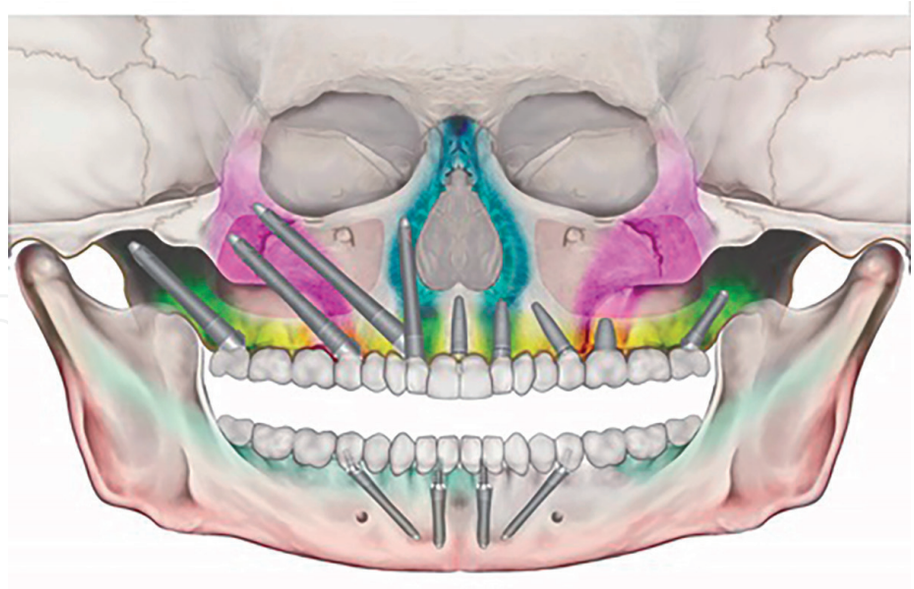

Figure 2.
Buttress implant concept and classification for the patient with jaws atrophy: Zone I/maxillary alveolar buttress, zone II/nasomaxillary buttress, zone III/zygomaticomaxillary buttress, zone IV/pterygomaxillary buttress, zone V/mandibular alveolar buttress and zone VI mandibular/basal buttress.

- Zone III/zygomaticomaxillary buttress: In 1998 Dr. P. I Branemark described zygomatic implants as a bone anchorage alternative with a design between 30 and 52.5 mm long that are inserted into the body of the malar bone [23]. Zygomatic implants offer adequate insertion torque. Immediate loading is usually more feasible compared to conventional implants. Up to 3 zygomatic implants can be placed on each side offering a full arch rehabilitation with an adequate polygonal distribution within the prosthetic arch.

- Zone IV/pterygomaxillary buttress: Tulasne and Tessier in 1989 were the first to describe the technique for the placement of pterygoid implants [24]. Pterygoid implants are implants between 15 and 20 mm long that allow a bone anchorage of up to 9 mm in the pterygoid process. Pterygoid implants are a viable option and if their main advantage is to decrease the prosthetic distal cantilever [25].

- Zone V/mandibular alveolar buttress: As in the maxilla, in the mandibular alveolar process we can use axial implants, short implants ≤8 mm and tilted implants with a mandible interforaminal anchorage as described in the "All on 4" technique. Subperiosteal custom implants are currently a new line of implementation with promising results. These custom implants generally obtain their retention in this buttress with monocortical screws [26].

- Zone VI/mandibular basal buttress: The basal mandibular buttress is a zone that offers a cortical bone which allows a primary stabilization when it is reached. This area has been used in severe bone atrophy, in oncological resections or after regenerative procedures in blocks. Currently there are various bone anchoring options such as the use of zygomatic mandibular implants, trefoil technique (Trefoil™) and bicortical implants (Strategic Implant®) that have offered adequate and salvage results in full arch rehabilitation treatment [27–29].

In general, full arch rehabilitation treatments with osseointegrated implants combine multiple techniques; regenerative and skeletal anchoring. The advantage of using skeletal anchors is that it allows a greater probability of immediate loading, a lower biological cost by not performing multiple regenerative procedures, less time in the treatment phases with a comparable global cost. The main disadvantages of using skeletal anchors include a higher learning curve, need for sedation or general anesthesia, and special surgical equipment that in most cases is available from commercial companies.

4. From analog to digital implantology

4.1 Computer guide treatment

Technological advances in conventional medicine and implantology offer resources in the diagnosis and treatment of full arch rehabilitation with osseointegrated implants. The digitization of clinical cases thanks to computed tomography and the buccal scanner allow the elaboration of surgical guides which restrict movements in the 3 planes of space. Although some studies confirm that there is no statistically significant difference in digital versus analog procedures, the digitization process in implantology can help avoid human errors and injury to anatomical structures, help to determine a drilling sequence with a greater probability of primary stability, reduce the Surgical times and improve the perceptions of patients by having a modern treatment [30].

When we perform computer-guided planning and see that regenerative procedures around implants are not required, flap-free surgery allows for greater patient comfort, recovery, and acceptance of treatment (**Figure 3**).

4.2 Computer-assisted dynamic navigation

Computer-assisted dynamic navigation has been commonly employed in medicine, recently been implemented for dental implant surgery. The dynamic navigation uses optical motion technology to see the implant placement in real time, this helps to perform a flapless surgery and gives the surgeon the confidence of knowing that the implant placement is adequate. However, dynamic navigation is a recent practice that has a high learning curve in addition to requiring specialized medical equipment [31, 32].

4.3 Biomodels in 3D

Stereolithography is a solid three-dimensional prototype obtained through the processing of data obtained from computed tomography or magnetic resonance imaging. In recent years, stereolithographic manufacturing has made great strides in the quality, resolution, and precision of manufactured parts and is becoming increasingly important in medicine and surgery.

Surgical simulation on a 3D biomodel makes it possible to consider measurements, positions and emergencies of the implants on the prosthetic arch. In addition, its usefulness in the placement of long implants with skeletal anchors allows the surgeon to be prepared for the surgical procedure and minimizes the possibilities of errors, favoring the results of the treatment [33] (**Figure 4A**).

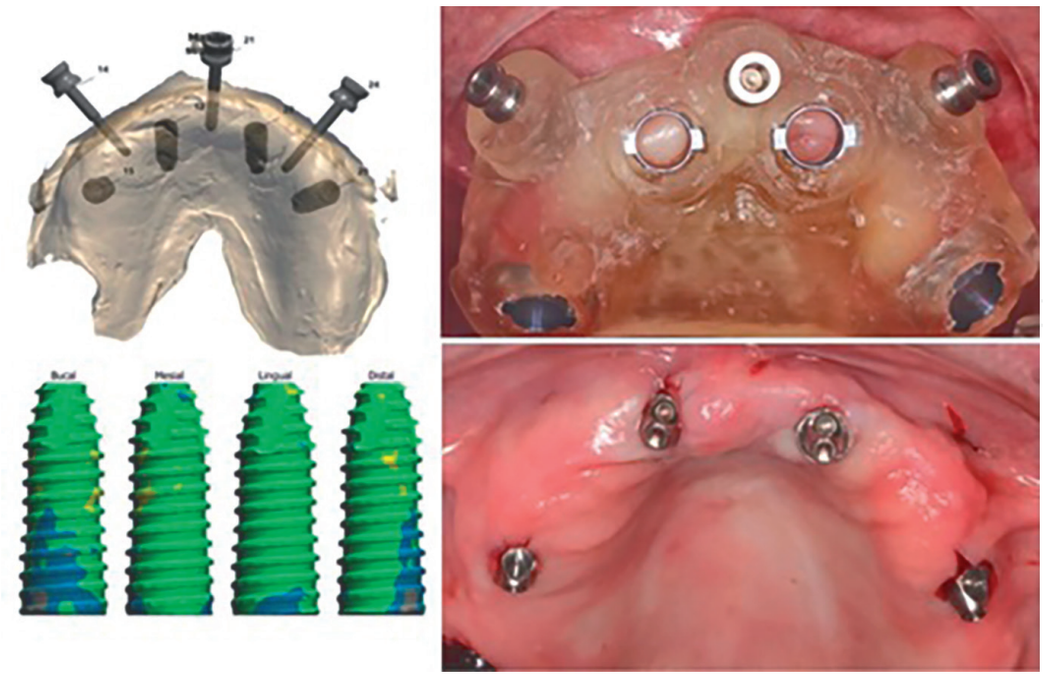

Figure 3.
Computer-guided surgery by means of tomography, scanner and plan (dental system® 3Shape and DIO implants). In this case, flapless surgery was performed.

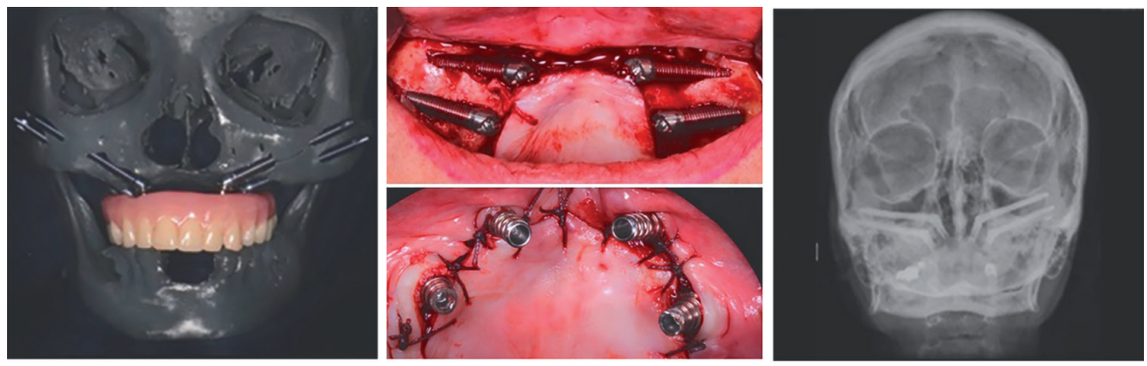

Figure 4.
A. Simulated surgery of Quadzygoma treatment on a biomodel in ABS (acrylonitrile butadiene styrene) with adaptation of an immediate retained prosthesis to temporary abaument. B and C. clinical application of Quadzygoma treatment (NeoArch – Neodent®).

5. Full arch rehabilitation in maxilla

5.1 Treatment of mild–moderate maxillary alveolar resorption

The maxilla is a paired bone located in the middle third of the face. In its upper part is the orbital cavity, in its middle part the nasal cavity and in its lower part the oral cavity. Towards the oral cavity, there is the alveolar process, which houses the maxillary dental formula and is the main area affected by edentulism. Although the maxillary bone is voluminous, it is quite light due to the presence of the maxillary sinus. A cavity that is part of the respiratory system through which air passes, is heated, humidified and filtered to pass into the respiratory tract. In general, in the treatment of mild maxillary alveolar resorption, it is not necessary to lift the maxillary sinus membrane, allowing

the placement of axial implants. If bone resorption is moderate, consideration should be given to regenerative procedures, sinus lift, or placement of tilted implants [34].

The choice of implants will depend on bone availability and prosthetic planning. Although there is no statistically significant variation when choosing narrows versus regular platform implants, we prefer implant placement greater than 4.0 millimeters in diameter in full arch treatment [35]. This has several reasons. Mainly the thickness of the implant walls and prosthetic solutions such as angled abutments available for implants of this diameter or greater.

An important consideration during planning and implantation is that the implants are prosthetically guided achieving a polygonal emergence towards the prosthetic arch. Once the implantation is achieved, an adequate wound closure must be carried out and the patient should be offered immediate rehabilitation with which the healing process will continue.

5.2 Treatment of severe maxillary alveolar resorption

The rehabilitation of a patient with severe maxillary atrophy represents a significant challenge for the surgeon and the prosthetist. Often these patients have undergone multiple treatments that have not been able to meet their demands and their mentality regarding the treatment is expectant. In addition to this, patients with severe maxillary atrophy have suffered a total collapse of all their stomaognathic structures, suffering an aging of the face with loss of self-esteem, esthetics and function.

To achieve a successful rehabilitative treatment, we must consider all our therapeutic options and have an anatomical knowledge of the possible anchor points for the placement of osseointegrated implants. During planning, we must evaluate the advantages and disadvantages of regenerative treatment of lost bone versus using long implants with remote skeletal anchors. Sometimes, regenerating the bone with grafts and membranes entails a higher biological and economic cost for the rehabilitative treatment or could increase the times for the definitive rehabilitation.

When conventional implants are an unfeasible option due to the degree of maxillary atrophy or when multiple regenerative treatments must be performed prior to implantation, anchors with long implants in the buttresses have solved this situation. Zygomatic implants are a suitable option. Arch treatments can be performed on 4 zygomatic implants, two on each side or in combination with conventional implants. Zygomatic implants offer adequate insertion torque and can be used as a rescue when conditions are not ideal with conventional implants [36]. Posterior tilted implants, tuberosity implants and pterygopalatine implants are posterior implants that have reduced the distal cantiliever of the prosthesis and support the biomechanical demands of rehabilitation (**Figure 4B** and **C**) [37].

6. Full arch rehabilitation in jaw

The mandible is an odd bone located in the lower third of the face and is shaped like a horseshoe. It is the largest bone in the face and the only one that moves thanks to the insertion of multiple muscles that participate in chewing. Unlike the maxilla, the mandible has a more corticalized bone, which in most cases allows immediate screw loading. The main anatomical structures of importance include the inferior alveolar nerve, the mental nerve, the insertion of the mylohyoid muscle and the floor of the mouth [38].

6.1 Treatment of jaw alveolar resorption

The rehabilitation of posterior regions and edentulous arches with mild atrophy, still allows the placement of implants of at least 8 mm or more in the posterior sector without compromising important anatomical structures such as the inferior alveolar nerve (IAN). In these cases, the biomicanic demands with the placement of 4 to 6 implants in the jaw allow adequate rehabilitation with screws [39].

When alveolar atrophy is moderate or severe, implants cannot be placed without invading the inferior alveolar nerve (IAN). In this situation, therapeutic options include regeneration of the lost alveolar bone, lateralization of the inferior alveolar nerve, placement of short implants < 8 mm and the placement of tilted implants anterior to the mental nerve in the All-on-4® concept [40].

Although the minimum number of implants required for a screw-retained prosthesis is 4, recently it has been described in jaws with severe atrophy the placement of up to 3 bicortical implants in the chin region in a Trefoil ™ concept with good results [41].

In general, the conventional surgical technique includes elevation of a full thickness flap to visualize the bone to the extent where the dental implants will be placed. If the residual bone crest shows irregularities, a bone plasty must be performed until a plateau is achieved and the implantation can be carried out according to the drilling sequence for each commercial company. When planning tilted implants anterior to the mental nerve (30° to 45°), it is essential to preserve the mental nerve and its labial branch to avoid neurosensory alterations of the lower lip. After carrying out the implantation of the desired number of implants, the hermetic closure of the wound is essential to avoid dehiscences and achieve a healing by first intention (**Figure 5**) [42].

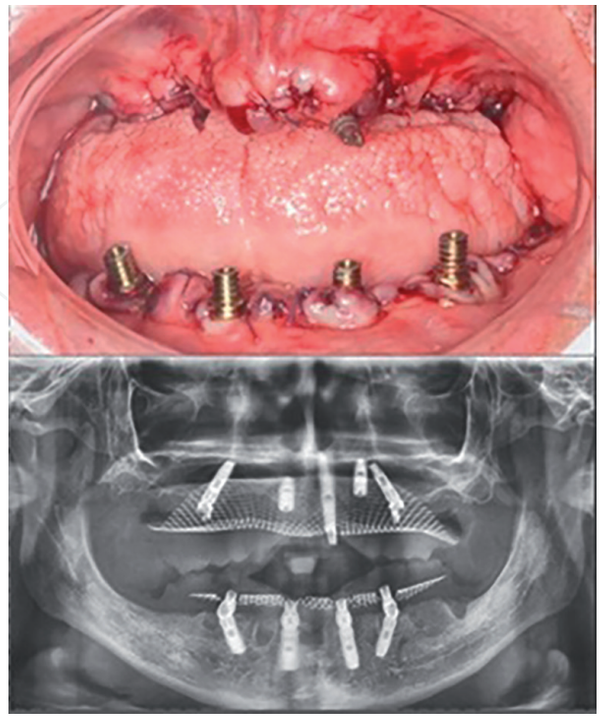

Figure 5.
Clinical and radiographic photograph of maxillary rehabilitation on 5 submerged implants (2 phases) and mandibular rehabilitation on 4 implants with immediate loading (1 phase).

7. Prosthetic considerations: Immediate and definitive prosthesis

7.1 Immediate prosthesis

For the adaptation of an immediate postsurgical prosthesis we will have multiple options that depend on the primary stability of the implants (greater than 35 N), the biotype and bone quality, the thickness of the cortices around the implants and the patient's commitment to comply precise indications such as diet and hygiene [43].

When the previous conditions mentioned are unfavorable, we can leave the implants submerged with covers screws, another option is to offer the patient a conventional removable total prosthesis retained to the implants by means of healing abutments. This favors certain retention and adaptation to the patient while the implants are not loaded during their osseointegration phase (2-phase protocol). When conditions allow an immediate screwed and supported load on the implants (1-phase protocol), this same conventional total prosthesis can be reduced from the flanks, the palate and/or the floor of the mouth to achieve a horseshoe shape, subsequently with a The acrylic relining is mechanically retained to the implants by means of temporarys abaments.

7.2 Definitive prosthesis

The long-term success of our prosthetic treatment depends on an adequate diagnosis and the detection of possible clinical difficulties before treatment. The planning of esthetic and functional prostheses requires the analysis of additional parameters such as smile height, lip sizes, permanence or absence of nasal and labial support given by the pre-maxilla, interocclusal and inter-arch space, functional demands, etc. For full arch reconstruction with dental implants there are several alternatives that we mention below:

- Implant-supported fixed prostheses (ISFPs): When there is an adequate interocclusal distance and the volume of hard and soft tissues has been maintained, fixed prostheses with implants allow a total reconstruction of the teeth with a natural emergence of the gingiva of the patient. Typically, these types of dentures are retained to the implants in a metal/ceramic material by means of a castable abutment (UCLA Abutment) [44].

- Implant-retained overdentures (IODs): Overdentures are total and removable dentures, but with an anchorage system. Overdentures mean fewer implants (2 to 4 per jaw). in older patients, they improve hygiene by being removable, compared to conventional complete dentures (CCDs), they significantly increase patient satisfaction, dental function and quality of life [45].

- Hybrid prosthesis: In addition to rehabilitating missing teeth, a hybrid prosthesis simulates part of the soft tissues. This type of prosthesis requires a minimum distance of 12 to 15 millimeters between the arch and esthetic parameters such as the height of the smile and the exposure of the lower teeth should be evaluated in more detail [46]. Cantilever length is also an important parameter that is to be evaluated when deciding to fabricate implant supported acrylic screw-retained hybrid prosthesis to minimize the risk of framework fracture. The researchers suggested a mandibular extension between 15 and 20 mm to minimize the risk of framework

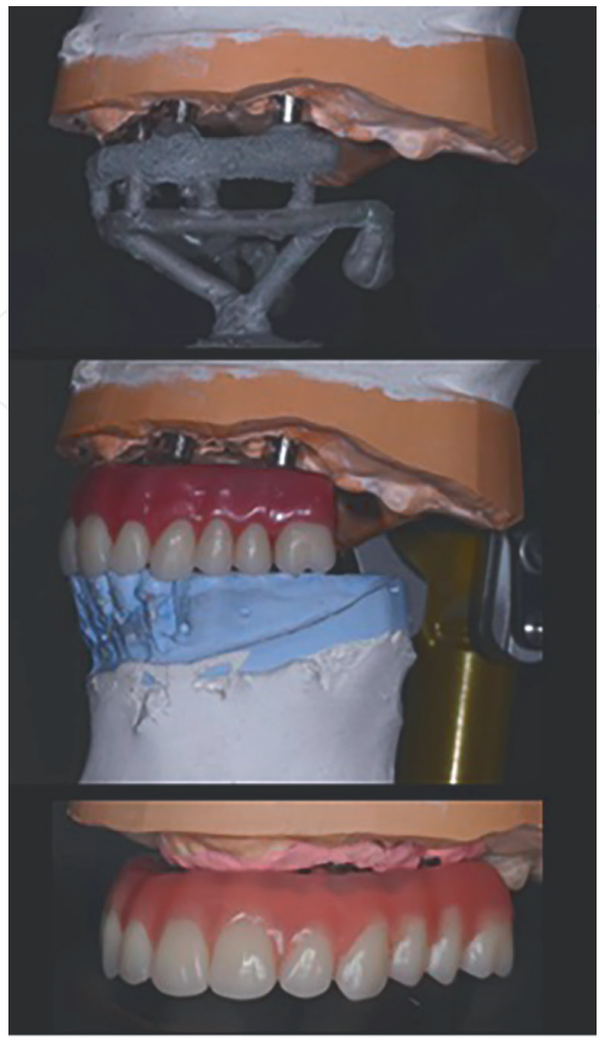

Figure 6.
Workflow for fabrication of hybrid metal-acrylic prosthesis.

fracture. Other authors recommended a cantilever length of 1.5 or 2 times of the anterior/posterior curve of the implants. Hybrid dentures are generally made of acrylic resin and metal or metal and porcelain (**Figure 6**) [47].

8. Complications

Full arch rehabilitation treatments with dental implants can have complications and failures. In general, complications may be related to the patient's systemic compromise, increased functional demand, surgical technique, post-operative care, design and type of prosthesis, etc. The overall success rate for dental implants is between 90–100% according to the study [48].

The most frequent prosthetic complications after the placement of an implant-supported prosthesis are: mucositis, loosening or fracture of the abutment screw or prosthetic components, and fracture of the acrylic or porcelain structure. Although most complications resolve favorably in follow-up appointments, it is essential to establish an adequate surgical and prosthetic management protocol to achieve predictable and successful long-term results [49, 50].

9. Where are we going

Medical and technological advances in medicine applied to current implantology have made it possible to have new rehabilitative treatments. Currently, the diagnosis of the edentulous patient, the design of the rehabilitation and the computer-guided surgery, allow the use of customized implants for full-arch rehabilitation. These devices are generally made of titanium and have a treated surface that allows osseointegration. In addition, they use skeletal anchors in the aforementioned abutments so that they have multiple fixations that work together to rehabilitate a complete dental arch. Currently, although their costs are high, they are accessible for very specific cases (**Figure** 7).

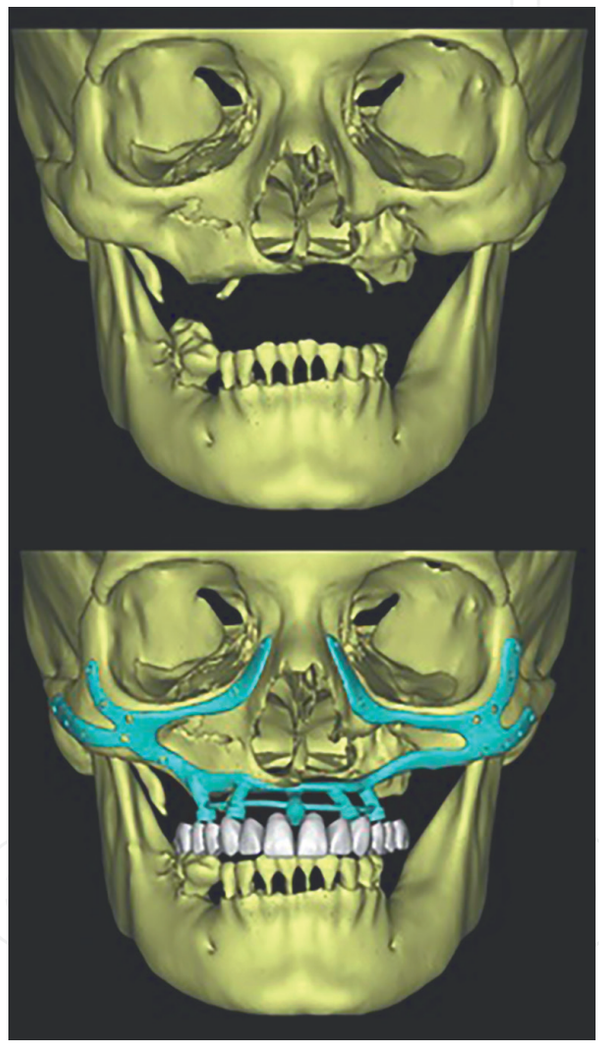

Figure 7.
Planning of a customized prosthesis in grade IV titanium for full-arch rehabilitation after tumor resection in an oncological patient.

10. Conclusions

Based on the current literature, full-arch fixed prostheses supported by a combination of axial implants, angled and placed in the different skeletal anchor points (buttress implant concept) can be considered a predictable and successful treatment modality for prosthetic rehabilitation of edentulous patients.

Acknowledgements

There are no acknowledgments to declare.

Conflict of interest

There are no conflicts of interest to declare.

Ethical approval

Institutional approval was not required. All cases were operated on by the author. All images are original and the author's own.

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