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Research Article

Maxillary Sinus Lift Surgery: "Description and Comparison of the Different Techniques" Clinical Case of Sinus Lift and Placement of Phibo TSH and TSA Implants

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Abstract

A bibliographic review was carried out on the different procedures and most common materials for augmentation or elevation of the maxillary sinus for the posterior or joint placement of endosseous implants. The objective of this work is to present a clinical case and review the existing literature. The topic has been widely discussed by different specialists, describing the different techniques, and also that it is a procedure with a high success rate. On the other hand, it can usually be performed in an outpatient clinic, respecting the concepts of asepsis that must be considered in oral surgery procedures: correct preparation of the equipment, sterilization of instruments and disinfection of the surgical field. That is, all instruments in previously sterilized airtight bags, surgical fields and sterile gloves, table and equipment, all properly disinfected. In addition, both the care team and the surgeon must have disposable sterile surgical caps and gowns. It is important to highlight that when handling bone fillers, they must also be packaged with the maximum sterilization protocols for their use.

Keywords

Maxillary Sinus, Maxillary Sinus Elevation, Bone Graft

1. Introduction

In the treatment of the posterior sector of the edentulous maxilla, it s frequently find great vertical bone resorption, or highly pneumatized maxillary sinuses that prevent us from placing implants with traditional methods. [18]. The most advanced techniques have been solving these problems, and sinus elevation with a subantral graft (Caldwell-Luc technique) has become a routine procedure with a very high percentage of long-term success. [2-4]. The surface of the implants influences osseointegration and can also constitute an important factor in the long-term survival rate of implants in the operated maxillary sinuses. Implants with a rough or treated surface, for example, TSA and TSH implants with Avantblast surface with double acid attack (Phibo Dental Solutions SL Sentmenat, Barcelona) usually have higher success rates than implants with a machined surface.

Dr. Tatum was the first to mention this technique, well described among others by Woo & Lee [5] and Danertt & Eisenmenger [6]. Doctors Boyne & James in 1980 were the

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ones who made the first report of a 4-year study of implants placed after maxillary sinus elevation and placement of an autogenous graft and its maturation for 6 months. [7]. Although the "open" technique of maxillary sinus elevation has manifest effectiveness [8, 9], the trends in recent years are moving towards less invasive, less traumatic procedures that help a better and quick recovery in implant surgery. That is why many authors return to "atraumatic elevation" using the Summers technique. [10-12] or its multiple modifications, especially if it is taken into account the contribution made by CBCT and planning techniques, being able to make the most of the remaining bone; as well as the multiple designs of implants with their different indications based on to the existing remaining bone and its quality. Leaving the technique open using a Cadwell-Luc, for when it is totally essential.

It ś known that pneumatization of the maxillary sinus can compromise the placement of implants in the posterior sectors; most authors have the classification established by Misch in mind. [13] that below 10 mm of bone height from the bone crest to the floor of the sinus, some procedure must be performed to increase the height or raise the floor of the sinus, all and that this aspect has changed in recent years with the advent of short implants and other techniques in cases of maxillary atrophy [14, 15].

The objective of this work is to describe the most common used surgical techniques for maxillary sinus elevation, both external and internal approach with Summers osteotomes or its modifications, evaluating contraindications and comprehensive management of the patient. And present a clinical case.

2. Anatomical Aspects

If it is made a brief review the anatomy of the maxillary sinus. The maxillary sinus, also called Highmore's antrum, is generally larger than any of the other sinuses and is located primarily in the body of the maxilla. It is actually present as a small cavity at birth and begins its development during the third month of intrauterine life, reaching its maximum development generally at the beginning of adult life, around the age of eighteen. The capacity of the average adult antrum is 10-15 ml, and its complete absence is rare. There are often subcompartments, diverticula, and crypts formed by bony and membranous septa. The maxillary sinus is pyramidal in shape with its base in the nasoantral wall and its apex in the root of the zygoma. The upper wall or floor in the adult is thin; It is located below the orbit and is the orbital cortex of the upper jaw. This cortex generally has a bony conduit for the nerve and the infraorbit vessels.

The floor of the sinus is the alveolar process of the maxilla. In front of the wall of the anterolateral or canine fossa, is the facial portion of the maxilla. The posterior or sphenomaxillary wall, which is of lesser importance, is formed by a thin sheet of bone that separates the cavity from the infratemporal fossa. The nasal wall separates the sinus from the nasal cavity toward the midline. The nasal cavity contains the outlet of the sinus, the maxillary ostium, which is located immediately below the roof of the antrum. The location of this opening prevents the possibility of good drainage when it is in a vertical position. [16].

The sinus is lined by a thin mucosa that is attached to the periosteum. The ciliated epithelium helps remove excretions and secretions that form in the sinus cavity. The thickness of the sinus walls is not constant, particularly at the floor and ceiling. Walls can vary in thickness from 2 to 5 mm at the ceiling and 2 to 3 mm at the floor. In the event that the posterior wall is penetrated causing entry into the infratemporal fossa, great care must be taken in the operating procedure, due to the presence of large vessels, such as the superior maxillary artery and vein. The infraorbital and superior alveolar vessels are frequently injured in fractures of the middle third of the face, leading to the formation of intrasinus hematomas. The innervation comes from the superior maxillary branch of the V cranial nerve, and the posterosuperior alveolar branch of this nerve innervates the lining mucous membrane. The blood supply depends on the infraorbital artery, a branch of the superior maxillary artery. And part of the collateral supply derives from the anterosuperior alveolar artery, a branch of the same vessel. [17]. Lymphatic drainage is abundant and ends in the submandibular nodes. The functions attributable to the maxillary sinus are: Give resonance to the voice. Note the change in the sound of the words of people with colds; Act as a reserve chamber to warm the breathed air; Reduce the weight of the skull.

The upper dental nerves run a considerable distance along the walls of the antrum. They are contained in small blood and lymph vessels in narrow channels that sometimes anastomose. Progressive expansion of the sinus in older people causes resorption of the inner walls of one or more of these ducts, and the tissue may become connective tissue that covers the structure comes into contact with the connective tissue of the mucoperiosteum of the sinus. This will cause compromise of the dental nerves if sinus inflammation occurs, which may cause pain similar to that of pulpitis. And on the contrary, this same resorption or the proximity of the dental roots to the sinus can cause dental pathology to be responsible for up to 30% of sinusitis, odontogenic sinusitis. [18].

3. Surgical Protocol

Surgery for the insertion of implants, like any other branch of dentistry, requires strict surgical protocols and a preoperative evaluation. Both panoramic radiography and computed axial tomography must be essential elements for the correct evaluation of the case. And secondly, although not of lesser importance, the assembled and articulated study models with their respective diagnostic wax-up that will dictate both the prosthetic plan to follow and the surgical guide for the placement of the implants. Askary [19], in a case reported in

2003, already indicated the importance of the protocol and multidisciplinary evaluation, recommending: I) Study and work models; II) Detailed medical and dental history; III) Radiographic studies (CBCT, panoramic, periapical); IV) Treatment options and differential diagnoses; V) Duration of treatment; VI) Patient motivation; VII) Cost; VIII) Quality and quantity of bone; IX) Quality and quantity of soft tissues; X) Type of periodontium; XI) Labial line (interlabial); XII) Lip support; XIII) Smile line; XIV) Emergency profile; XV) Presence and management of diastemas; XVI) Surgical guide; XVII) Selection of the type and size of implant (s); XVIII) Forecasting the shape and management of provisionals (diagnostic wax-up); XIX) Occlusion, type and pre and post treatment modifications; XX) Number of missing teeth; XXI) General periodontal condition and pre-surgical management; XX) Orthodontic considerations; XXI) Anatomical considerations; XXII) Condition of neighboring teeth.

It is noteworthy that the size and morphological characteristics of the maxillary sinus can be evaluated by means of CBCT. The maxillary sinuses usually have an approximate size of 12-16 mm in width. The height of the crestal bone and the distance between the floor of the sinus and the floor of the nostril is usually located at 11-15 mm, which must be taken into account for the insertion of implants of a minimum length of 10 mm. The osteoconductive characteristics of the biomaterial used and its homogeneous intrasinus placement in the sinus lift must also be assessed since they may affect the final dimensions of the operated sinus, which should not be less than 10 mm. The existence of septa in it is usually approximately 20%. CBCT also allows measuring the width of the maxillary sinus mucosa (approximately 2-3 mm). [23].

In summary, it is agreed that in a very special way it is recommended: a.-Analyze the alloveolar relationship, which will determine the position of the implants and their restoration possibilities. An attempt should be made to achieve a crown- implant ratio of at least 1:1, and axiality in the position of the implant with respect to the axis of occlusion. b.-Develop a viable prosthetic plan.

Placement of a sufficient number, length, and diameter of implants to meet prosthetic loading needs and minimize cantilevers or overhangs. If extractions are required in the maxillary sinus sector, delay them as long as possible to avoid pneumatization of the sinus. Finally, four suggestions: The more mesial the position of the implant, the better its prognosis. The more residual alveolar bone, the better the prognosis of the implant. Isolated implants or implants in terminal areas have a very poor prognosis and the wider the implant, the better the outcome prognosis, aspect in controversy at the moment [20].

4. Indications and Contraindications for Maxillary Sinus Lift Surgery

The two alternatives to perform maxillary sinus elevation have different uses, indications and contraindications that it is summarized globally and before describing each of them separately (Table 1).

4.1. Atraumatic Maxillary Sinus Lifting with Osteotomes (Figures 1 and 2)

This technique, which, as it is been said, was described by Dr. Robert Summers, based on the application of instruments to compact, widen, transport and elevate the bone both in the anterior areas and in the posterior region of the maxilla and that everything and that have been described in different ways. methods, they are all based on osteotomes [21-23]. The floor of the sinus is of a very fragile and thin consistency in most patients comparable to type IV bone. Generally, in this area it can be in other to prepare the bed for the implant without using drills, exclusively with osteotomes. The design of the implant is also of great importance when penetrating the cortical area of the floor of the maxillary sinus, since it is desired it to ossify completely covering its apex.

Table 1. *Most common indications and contraindications for maxillary sinus floor elevation.*

Caldwell-Luc technique for maxillary sinus elevation	
Indications:	*Atraumatic Summers osteotome technique for sinus lift Indications:*
- When you have less than 4 mm bone height. / -When it is required to graft a large amount of material for the placement of several implants. / -Preferably in non-smoking patients, due to the fragility of the sinus membrane, the unfavourable immune response and poor healing.	- Currently under review, it accepts parameters of between 8 and 4 mm minimum height.
	Advantages:
	- With this technique it is managed to compact the bone in such a way that the bone density can be increased and that it will be in intimate contact with the implants to be placed, therefore obtaining primary stability that in turn will prevent

to a certain extent the possibilities of resorption. / -1 to 2 mm in height can be obtained using the bone in the area itself, allowing these microfractures to ossify favourably, covering the apex of the implant and with minimal risk of perforating the membrane of the maxillary sinus.

Contraindications:

In patients with some serious immunological disease and sinusitis. As well as those who are immunosuppressed or at surgical risk and those who are undergoing treatment with radiotherapy or chemotherapy. / -Abusive use of alcohol, drugs and tobacco. / -Relative: Alveolar scars (maxillary orthognathic surgery). / -Patients with neoplasms. / -Patients with severe allergic rhinitis (especially traumatic). / -Patients with severe weakness. / -Severe infections. / Severe uncontrolled pathologies. / -Osteoporosis (under discussion).

Figure 1. *Traditional technique with concave osteotomes + graft + placement of TSA implants (Phibo Dental Solutions, Sentmenat Barcelona).*

Osteodensification (Versah system): (Figure 3)

In conventional implant site preparation, bone is removed with drills to "make room" for the implant. In this technique, the bone is not removed, but compacted with burs and autografted. Additional heights of 1-2 mm can be achieved and it will be needed to know exactly the bone height it is up to the lower cortex, and to this end, in the study of the case it will use a panoramic x-ray and CBCT, to carry out adequate planning. But it should not be disregarded the possibility of taking intraoperative radiographs. All the preparation will be done exclusively with osteotomes. Begin by introducing osteotome No. 1 until resistance is felt in the floor of the sinus (1 or 2 mm less than what it is found measured).

Next, osteotomes 2 and 3 are used. It will be with the number 3 that the most resistance will be noticed (if osteotomes 3 and 4 penetrate easily think about whether it is anatomically possible to place a 5 mm implant). With osteotome No. 3 Reach the exact length of the height of the sinus, but without exceeding it. To be sure not to overpass ourselves thry should always be taken periapical x-rays, to have an accurate control during the intervention.

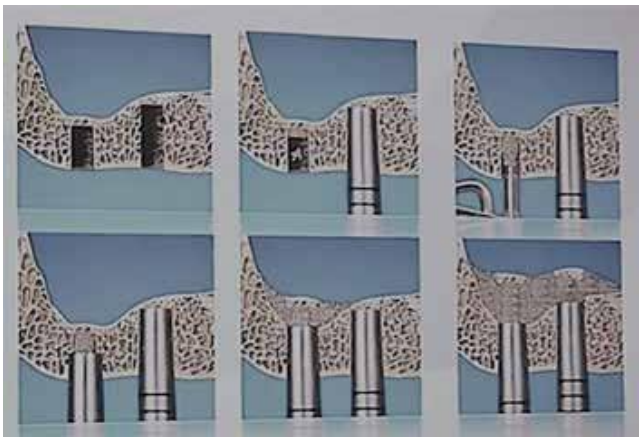

Figure 2. *Traditional Summers technique with concave osteotomes + bone filler.*

Studies carried out by Boyne demonstrate that the hemispherical tip implant promotes bone formation in penetrations that do not exceed 2 to 3 mm in height. In these studies, it is also observed that in penetrations greater than 4 or 5 mm this spontaneous bone apposition does not occur. [24].

Similarly, in 1997, Geiger carried out histological studies in which the good tolerance and response of Shneider's membrane to accidental perforation with ceramic implants could be seen, observing that after three months the membrane with its ciliary epithelium had regenerated, recovering your metabolism [10-12].

In this technique it is extremely important to know: 1.-Osteotomes must enter with a goal firm weights, but of millimeter in millimeter always depending on the type of bone; II.-After inserting the entire desired portion of the osteotome, it should be left in the bed for sufficient time to allow bone expansion and II-I.-The osteotomes should be removed from the bed by turning them carefully and never abruptly.

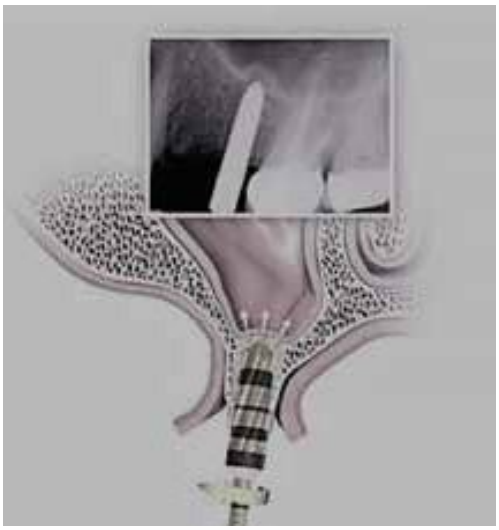

Figure 3. *Adapted from Densah Versha* Coorp. Osteodensification with burs (Densah)*.*

4.2. Atraumatic Lifting Without Bone Injert (Osteoexpasion and Densification)

If the implant that it is going to place is 3.3 mm in diameter, the last osteotome to use will be number 3. If it is placed a 4 mm diameter implant, it will be osteotome 4. If the bone is type III it should de placed place a 4 mm diameter implant, and if it is type IV the the implant will be 4: mm in diameter or if possible it would be prepared with the osteotome to place a 5 mm implant. If so, and it is not necessary to obtain initial stability, a 6 mm implant could be placed if the bone width allows it. Regarding the type of fixation, current literature advocates self-tapping cylindrical and conical implants with atraumatic apex.

It is thought that this variation in osteodensification (OD) arises from the need for increasingly less invasive techniques. This is how retrograde milling arises, developed by Huwais & Meyer (2017). This technique was implemented thanks to the use of Densah® drills, which are specially designed to increase bone density, displacing and condensing the bone tissue surrounding the drill, which allows its expansion [37]. In studies carried out in 2019, it has been demonstrated mean bone crest expansions of 2.36 ± 0.31 mm and 1.8 ± 1.1 mm respectively. In the first instance, the geometry of the Densah® drills (Versha®, Lisbon, Portugal) allows for precise cutting of the bone by rotating clockwise (conventional rotation) in the first drill, and then rotating in reverse mode at a rotation speed of 800 to 1,500 rotations per minute (rpm), with copious irrigation of saline solution to prevent overheating of the bone. This movement allows the soft bone of the implant osteotomy to be condensed in a lateral and vertical direction (compaction autograft). With this, greater bone volume and density is obtained, which increases bone contact with the implant, with the consequent increase in insertion torque levels, reduction of micro movement and expansion of alveolar ridges. [37].

4.3. Atraumatic Lift with Bone Graft

Whenever a lift of more than 2 mm is desired, it must be used the graft lift technique. In some occasions, even if it is are going to be raised 2 mm in type IV bone, bone graft is also used, although in this case it can be easily obtained from the same patient, given the small amount. Atraumatic elevation with graft basically consists of the same principles, but with the particularity that before elevating the mucosa with osteotome No.3, fill the neoalveolus that was prepared with the graft material and reintroduce the osteotome to the floor of the sinus, no further. In this way, the amount of interposed bone and fluids that the mucosa will displace is much greater, and the possibilities of perforation of the membrane are very low. It is advisable to perform the Basalva maneuver to assess the integrity of the membrane.

Figure 4. *Adapted from Chairside images. Atraumatic sinus balloon elevation.*

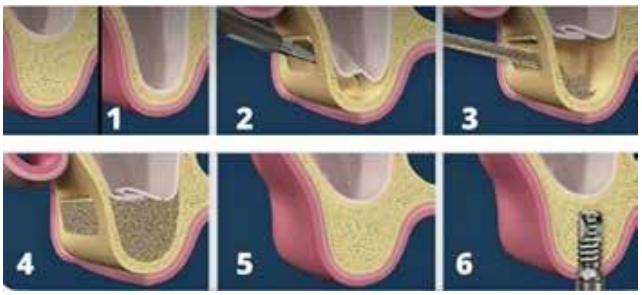

Figure 5. *Sinus lift technique with lateral window* ***(Caldwell Luc)*** *and TSA implant placement (Phibo Dental Solutions, Sentmenat Barcelona).*

There is also the technique of transalveolar elevation of the maxillary sinus with the MISE system (Maxillary Indirect Sinus Elevation) Martina, Padua, Italy) [37] (consists of a system of burs and stops that allows the maxillary sinus to be raised atraumatically and gradually to a height of 5 mm to a height of 10 mm above the initial lifting situation and; the predictable (progression of 1 mm each time) preserving the Schneiderian membrane, and allowing the introduction of the filling material. The MISE technique is based on the use of a system of drills and stops that allows the maxillary sinus to be gradually and transalveolarly elevated to a height of 5-10 mm. above the initial situation. Generating an adequate three-dimensional space for the introduction of the filling material and achieving bone gain of the alveolar ridge with compromise vertical bone miso [23].

Another innovative approach has been proposed for cervical sinus elevation by incorporating a piezoelectric instrument that gives osteotomes a simpler and more atraumatic way of use. The surgery begins with a round drill or directly with a concave osteotome depending on the density of the bone. A diamond bur is installed in the piezoelectric device and performs the osteotomy up to 1 mm below the Schneiderian membrane.

Subsequently, a sequence of osteotomes performs the fracture and elevation of the cortex and filling of the sinus. [23].

The technique of translaveolar elevation of the maxillary sinus through the use of a balloon [Figure 4] that, when inflated, allows the elevation of Schneider's membrane, with a high success rate and a relatively short learning curve. This transcrestal sinus lift is performed through an osteotomy of less than 3.5 mm and the incorporation of a balloon specially designed for this. Doctors Benner and Bauer designed the Balloon Lift Control system for the Meisinger company (Germany), a surgical box that consists of multiple guide sleeves, for the controlled milling of the sinus floor, the elevation of the last millimeter of bone with a millimeter osteotome and the membrane detachment with a balloon catheter. These authors performed a crestal access through a circular incision, thereby eliminating the elevation of a large mucoperiosteal flap and, therefore, a morbid postoperative period. [38].

This more traditional technique is known as external or modified Caldwell-Luc. The modern sinus lift technique is based on the method of Dr. Tatum (1986) [26]. Already in the seventies, this author modified the CaldwelLuc surgery (opening of the maxillary sinus through the canine fossa), and proposed performing a U-shaped osteotomy, introducing the bone segment (partially drilled in the cranial or upper area) into the maxillary sinus., elevating the sinus mucosa and filling the freed space (caudal third of the maxillary sinus) with autologous bone. After a period of healing and bone maturation of minimum 6 months, it can be considered to place implants.

Figure 6. *Initial orthopantomography of the case.*

Figure 7. *Extraction as atraumatic as possible of the rest of the tooth 2.6.*

They can insert the implants according to the corresponding technique into the existing and augmented new bone. It is currently accepted that if the renal bone is more than 4-5 mm and/or the implant is stable, they should be placed at the same surgical time. [13, 27]. At the beginning of the technique, two options were proposed: I:-Onlay-type augmentation of the upper jaw. The bone graft introduced or interposed is fixed with implants, this is a block type that is generally obtained from the chin or the patient's own iliac crest. This technique could cause problems at the time of prosthetic rehabilitation, since the shape of the alveolar ridge is modified and the occlusal interalveolar distance ended up being considerably reduced in most cases. II.-Inlay type upper jaw augmentation. Autologous, homologous, heterologous or alloplastic granulated material is introduced, soaked in blood, PRP or physiological saline. It is recommended that it be of high granulometry (between 300 and 400 microns). With this technique, both the raised maxillary mucosa and the configuration of the alveolar ridge are not they modify. The window made can be moved up, removed, crushed and used or repositioned in the bed.

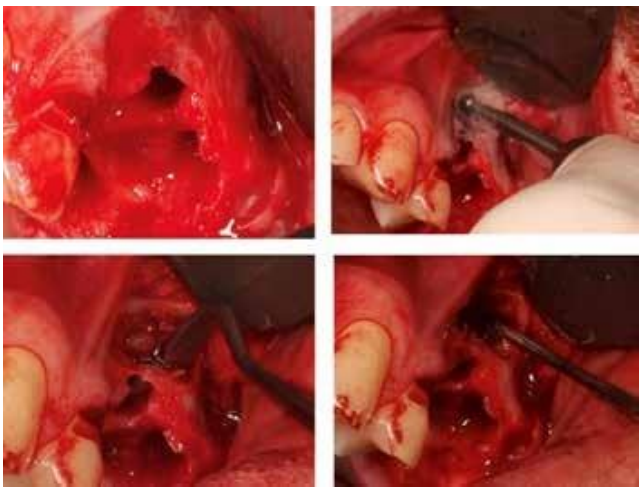

Figure 8. *Surgical bed and opening of the lateral window of the sinus and detachment of Shneider's membrane.*

Figure 9. *Implant placement at 25 and 26 S4 TSH (Phibo Dental Solutions, Sentmenat Barcelona) and Implants placed and first loading of the Normon-Biotech® graft, Barcelona, Spain) through the lateral window.*

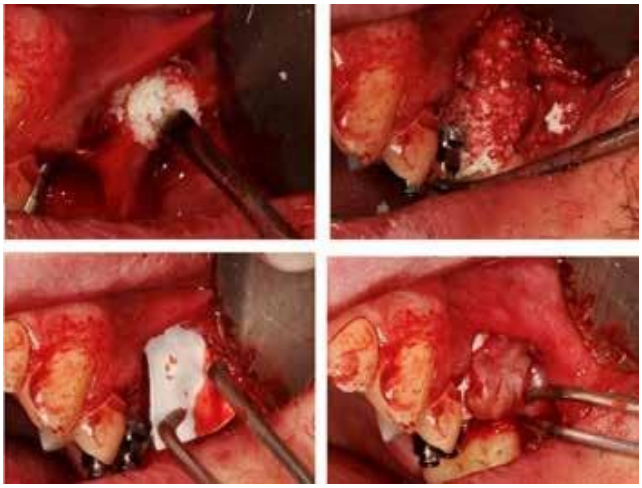

Figure 10. *Final filling of the lateral window and placement of collagen membrane (Normon-Biotech®, Barcelona, Spain) and repositioning of the flap.*

5. Different Kinds of Grafting Materials

A number of researchers reported a high success rate for using autogenous bone grafts and composite materials containing autogenous bone. Use of alloplastic grafts also produced favorable results. Zinner et al. described alloplastic grafts as a good alternative to autogenous bone grafts. Regarding the applications of inorganic biomaterials, bioactive materials based on calcium and phosphates have been used either alone or in combination with natural organic materials. Porous bone minerals showed great osteoconductive properties. Leonardis et al., has reported calcium sulphate as a suitable material for sinus lift applications.

The most commonly used graft material is autogenous cortical from the mandibular branch or symphysis, or even cancellous iliac crest. New graft materials (such as xenografts, deprotonated bovine, platelet rich plasma) are being used in combination with autogenous graft and providing promising basal support for implant insertion. Success rate improves remarkably with immediate implant placement in a good quality basal bone support. However, immediate implant placement is not recommended if site is lacking a good quality bone support. [25,39]. Always taking in count that any kind of all of these materials will be substituted by natural bone, this means that they just serve as promotors of the new natural bone and to keep the space in the process of it.

6. Clinical Case

(Dr. Carlos Parra R.) April 2023

A case of left sinus lift with lateral window technique is presented, with placement of immediate Phibo TSH implants (Phibo Dental Solutions, Sentmenat Barcelona). In Figure 6, you can see the initial situation before the extractions. The elevation of the left maxillary sinus and placement of implants in 25, 26 and 15 is planned. An implant is also planned in position 46. Figure 7 specifies the atraumatic extraction of the rest of tooth 2.6. In Figure 8, the lateral window lift procedure of the maxillary sinus. Figures 9 and 10 show the final phases of the surgical procedure.

Figure 11 represents the OPG of the case at the end of the procedure.

Figure 11. *Final radiograph with external window elevation of the maxillary sinus and placement of TSH S3 implants at 25 and 26 y; TSA S4 at 15 + TSA S4 at 46. (Phibo Dental Solutions, Sentmenat Barcelona).*

7. Discussion

Maxillary sinus lift surgery is one of the surgical procedures that requires comprehensive training of the implantologist and of course of great interest for daily practice.

Since more and more patients are asking to be rehabilitated with implants. In 1999, doctors Joel L. Rosenlicht and Dennis P. Tarnow [28] did a histological study on the osseointegration of hydroxyapatite implants placed simultaneously with external

sinus elevation. They used fillers in a mixture of demineralized bench bone, osteograft and autologous bone collected at the time of drilling. The importance of this histological study lies in its results of perfect and problem-free osseointegration after 2 and a half years since its placement together with the fillings. Another study by doctors Coatoam & Krieger [29] analyzes the results after four years of atraumatic maxillary sinus elevation, the data from their study in which they used bench bone of between 300 and 500 micron granulometry mixed with saline solution and 1.25 mg of tetracycline along with autologous bone of the area; reveals a success of 97.1% of a total of 123 implants, which forces us to think that conventional protocols continue to be a useful parameter.

In the latest publication by Atiq et al [1] They conclude that there are no significant changes when comparing both ways of addressing the problem of lack of bone in the posterior maxillary areas, that is; that both internal and external techniques are valid and successful if appropriate clinical protocols are followed.

On the other hand, it is already known from classic studies that the success of implants placed delayed after a lift or at the same time performing it has the same range of long-term success, as long as strict surgical rules are followed [30, 31]. And everything and it is not a technique free of complications. [32-34], the success data is supported by recent studies [35, 36].

8. Conclusion

Finally, with all the information found, it could be concluded that maxillary floor elevation surgery today has several techniques depending on the bone needs and circumstances of the case. That in the vast majority of cases: it is a routine procedure in the clinical practice of implantology and that if the protocols that have been described are followed, the success is very high even with the placement of the implants at the same time as is the case described in the article.

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The authors declare that there is no conflict of interest.

Abbreviations

OPG	Orthopantomography
PRP	Platelet rich plasma
rpm	Revolutions per minute
CBCT	Cone Beam Computed Tomography
OD	Osteodensification

Conflicts of Interest

The authors declare no conflicts of interest.

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