Evaluation Study

MANAGEMENT OF CAWOOD & HOWELL CLASS V AND VI BONE ATROPHIES OF THE MAXILLA WITH AUTOLOGOUS BONE GRAFTS

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ABSTRACT

Rehabilitation of severe bone atrophy requires adequate bone volume. Autologous bone is the gold standard. The goals of bone grafts are a predictable formation of vital bone and the integration of implants inserted into newly formed bone. The aim of this work is to evaluate the use of autologous bone grafts in the management of severe maxillary atrophy. Fifteen patients (6 males and 9 females), with a mean age of 54.6 years, were included in the study. All 15 patients underwent onlay grafts. In 9 cases, in association with the graft, a large bilateral maxillary sinus lift was performed. In two cases, the lift was unilateral. The timing of the graft evaluations was as follows: T_0 (pre-operative situation), T_1 (post-operative situation), and T_2 (situation 4-5 months after surgery at the time of implant placement). Radiographic and clinical measurements of the grafts demonstrated average resorption due to the phenomena of graft engraftment of 28.5% in height and 31.3% in thickness. In relation to the criteria taken into consideration, a 94% success rate was achieved in the three-dimensional rehabilitation of the upper jaw, which allowed for the prosthetically guided insertion of 85 implant fixtures.

KEYWORDS: *bone atrophy, autologous bone graft, onlay, implant insertion*

INTRODUCTION

Background

12.8% of the population over the age of 65 presents a picture of total edentulism of varying degrees: the situation is disabling because it causes a loss of the individual's chewing, phonetic and aesthetic ability (1-4). Following the loss of dental elements, the jaws show a progressive and irreversible reabsorption of the alveolar process. This bone atrophy is mainly due to the variation of mechanical stresses applied to the alveolar structure. Frost's mechanostatic theory (5, 6) shows how the variation of loads leads to a substantial modification of the metabolic balance between osteoblasts and osteoclasts. There are also numerous conditions that favor and encourage reabsorption, such as endocrine and metabolic factors, as well as the type of diet: hormonal variations due to menopause, decrease in bone mineral content after the age of 50, previous presence of chronic periodontal disease (7), etc. In this regard, some Authors (8) have demonstrated that

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infra-osseous pockets and widespread horizontal resorption preceding the loss of the elements accentuate the loss of tissue when the patient becomes edentulous.

Osteoporosis is an imbalance between osteosynthesis and osteolysis that occurs after age 50, but various studies underline how this systemic condition rarely involves the jaws (9-12). The only problems due to osteoporosis are specific to the surgical intervention for aspects related to the drugs taken for the therapy (13).

There are methodologies to rehabilitate the different types of atrophy to restore both the dental arches and the correct skeletal relationships, with a correct muscular function attached. *Guided bone regeneration* (14) is a successful technique in minor transverse and vertical defects in cases of partial edentulism for dehiscences and peri-implant fenestrations. The most used option for severe maxillary atrophy is graft biomaterials. The choice of graft material is based on the defect to be corrected: autologous bone grafts (gold standard) can be used to treat moderate or severe atrophy. Three reconstructive methods exist: *onlay* grafts (apposition), *inlay* grafts (interposition), and large maxillary sinus lift.

The bone in the posterior regions of the maxilla is generally of poor quality (class III and IV according to Leckholm and Zarb) (15): using only autologous bone, we reproduce the same bone quality while using bovine bone, the clinical perception is comparable to a type II quality.

Rationale and objectives

Rehabilitation of severe bone atrophy requires adequate bone volume. Residual ridge insufficiency is a limitation to the placement of osseointegrated implants in the maxilla. Over time, surgical techniques have improved, and so can different types of implants. Autologous bone is the gold standard for its osteogenetic properties (16-18). A limitation of its use is the need for an extra-oral donor site if reconstructive needs are high. Various alternative materials (19) have been studied to regenerate bone atrophies with good results in specific situations (20, 21). Severe bone atrophies of the maxilla can be treated by harvesting from an extra-oral site and grafting *inlays* and *onlays* (22, 23). Some studies (24, 25) have demonstrated lower resorption and better integration of intra-membranous bone (calvaria) compared to endochondral bone. Recent studies (26, 27) have shown that these differences are due to the microarchitecture of the cortical bone compared to the medullary one.

The aim of this work is to evaluate the use of autologous bone grafts in the management of severe atrophy of the upper jaw. The primary objective was to evaluate the reconstructive success in terms of three-dimensional volumetric rehabilitation of the maxilla in the function of a correct prosthetically guided implant positioning. This also allowed to evaluate the resorption of the graft during creeping substitution. The secondary objective was to evaluate the clinical success and the marginal peri-implant resorption of the implants inserted with a two-stage protocol before the prosthetic rehabilitation. The insertion phase of the endosseous implants followed the reconstructive phase for 4-5 months. Evaluating the integration is another parameter that allows us to indirectly define the success of the graft:

- only a successful graft allows a prosthetically guided positioning in the three planes of space that allows to compensate for the morpho-functional losses due to atrophy;
- only a successful graft allows a precise preparation of the implant site that facilitates the process of osteo-integration: the perfect congruence of the bone walls of the implant bed with the titanium surface is one of the fundamental prerequisites for achieving the osseointegration of the implants (28);
- only a successful graft guarantees a vital bone volume between 25 and 35% with a failure limit set at 20% (29-32). This limit has been recognized as the minimum threshold that allows the osteo-conductive process of bone healing and that guarantees intimate contact between the titanium surface and the bone (33).

MATERIALS AND METHODS

Patient selection

Exclusion criteria:

- insufficient oral hygiene;
- habit of smoking;
- alcohol or drug abuse;
- uncontrolled diabetes;
- liver disease: alcohol abuse with cirrhosis problems and viral B and C infections;
- HIV;
- patients undergoing therapy for neoplasms;
- collagenopathies: SLE and rheumatoid arthritis;
- severe heart disease;

- psychic lability;
- acute odontostomatological infections;
- state of pregnancy;
- limited opening of the mouth (inability to use the surgical guide and drills).

The inclusion criteria of the study are summarized as follows:

- classes I and II according to the ASA classification;
- total or partial edentulism at the level of the upper dental arch;
- maxillary atrophy of classes V and VI according to the Cawood and Howell classification;
- absence of systemic and local pathologies that contraindicate the execution of the surgical procedure under general anesthesia;
- patient compliance and motivation;
- non-smokers for at least 10 years;
- good oral hygiene and absence of periodontal disease in the residual dentition;
- skeletal class that can be compensated with *onlay* grafts;
- absence of oro-sinusal pathologies (in procedures including maxillary sinus lift);
- acceptance of an implant-prosthetic treatment;
- informed consent of the patient and acceptance of the treatment plan using a fixed prosthesis supported by implants;
- age greater than 18 years.

Other aspects to consider are:

- patient oral hygiene, caries receptivity, clinical signs of smoking, periodontal evaluation;
- bi-arch inspection and palpation: evaluation of the residual dentition, prosthetic rehabilitations, mucosa, edentulous crests and bone lesions;
- topographic analysis: three-dimensional anatomical peculiarities, limitations from physiological and/or pathological anatomical structures. These assessments are carried out by creating study models mounted in an articulator and instrumental examinations, in particular latero-lateral projection x-rays, orthopantomography, intraoral x-rays and CT;
- analysis of occlusal relations, extrusion of residual elements, verification of para-functions, TMJ problems.

Study design

The study included 15 patients (6 males and 9 females) with an average age of 54.6 years. All 15 patients underwent onlay grafts. In 9 cases, in association with the graft, a large bilateral maxillary sinus lift was performed. In two cases, the lift was unilateral.

Pre-operative planning

The selected patients followed a diagnostic-therapeutic process that began with planning the surgical intervention and prosthetic rehabilitation. The patients all presented with severe atrophy of the upper jaw and in some cases the clinical picture was aggravated by extensive pneumatization of the maxillary sinus.

The case study was carried out starting from the extra-oral and intra-oral objective examination. The face and perioral tissues were assessed both during the interview (functional analysis) and through photographs - frontal, right and left lateral - (static analysis) focusing on the interlabial relationships, the exposure of the anterior elements, the length and support of the soft tissues of the lips. Often, a decrease in the length of the face (middle third), the disappearance of the labiomental angle, the retrusion of the upper lip, the prognathic aspect of the chin, the deepening of the nasolabial fold and the increase in the nasolabial angle were noted. All these situations must be compensated for from a surgical point of view and not with prosthetic compromises. Then the objective examination of the oral cavity was performed which allowed us to analyze above all the three-dimensional situation of the maxilla, the interarch distance, the degree of opening of the patient, focusing especially on the areas with the greatest problems. These assessments were helpful in studying the case from a radiographic point of view, which was based on orthopantomography, intraoral radiographs, latero-lateral teleradiography and CT with the relative three-dimensional reconstructions.

The main planning was studied using CT with Dentascan programming (with correct inclination of the scanning plane on the Scout View) and using the relative computerized reconstructions. It consists in calculating the volume of the

atrophic site. The objective was to plan the prosthesis at this time, which was subsequently created by inserting endosseous implants. The necessary bone was established by means of simulated assessments with insertion of implants and creation of the prosthesis. At the end of the processing, the operator had designed the morphology of the necessary graft and the operative need for *onlay* grafts and large maxillary sinus lift. The interventions were planned according to the deferred method ("*two stages*"): a bone regeneration intervention and a second intervention for the insertion of the implants (34).

Preoperative pharmacological protocols and general anesthesia

The supportive pharmacological therapy was chosen based on the type of intervention which is invasive with two distinct operating sites:

- oral antiseptics: therapy with chlorhexidine was started 3 days before the intervention. At the time of the intervention, a rinse was performed for at least one minute. In the postoperative course, two daily rinses were indicated at least until the removal of the stitches;
- antibiotics: amoxicillin and clavulanic acid 2 grams 1 hour before the intervention, followed by 1 gram twice a day in the postoperative period. Since the interventions were performed under general anesthesia, the preoperative administration was done intravenously at the time of the intervention;
- anti-inflammatories/analgesics: the administration of anti-inflammatories began intravenously during surgery and continued for 4-7 days, depending on the inflammatory response to the surgery (proportionate to the invasiveness and duration). Nimesulide 1 gram was used twice daily. Given the intense surgical trauma, corticosteroids were injected in a single dose during the final stages of the operation to prevent postoperative edema;
- sedatives: benzodiazepines were administered intramuscularly 30 minutes before surgery as premedication.

Bone harvest from the anterior iliac crest

For all interventions, the iliac crest was chosen as the donor site due to the characteristics of the harvest and the amount of bone needed. The skin at the harvest site was thoroughly disinfected with povidone-iodine. At the sampling site, a subcutaneous infiltration of 0.5% bupivacaine was performed, with 1:200,000 adrenaline. To avoid sectioning the cutaneous branch of the iliohypogastric nerve, the skin, above the incision site, was manually retracted craniomedially for 2-3 cm, so that the incision, upon release, was in fact displaced laterally to the crest itself.

The osteotomies delimiting the extent of the harvest were performed with hand instruments and oscillating saws, trying to limit the use of the latter due to the problems caused by heating (35) and by the reduced vision and sensitivity. The osteotomic incisions that delimit the extent of the harvest horizontally, laterally and in depth along the medial face of the iliac crest, were performed according to the dimensions of the pre-established harvest. Furthermore, the other team, at the same time as performing the crestal harvest, began preparing the receiving site.

The operations continued with the cranio-caudal extension of the harvest with two osteotomic incisions parallel to each other, at a predetermined distance, on average 5-8 cm. These osteotomies were connected to each other by means of an osteotomy performed for the medial part of the roof of the crest. The lateral incisions were then extended, also parallel to each other or slightly convergent.

The bone harvest is delicately detached from the posterior cortex, completely interrupting the medullary bone that partially remains attached to the cortex of the harvest from the medial surface of the iliac crest. Upon completion of the bone harvest, additional medullary bone was harvested from the iliac crest using alveolar spoons, through the residual cavity.

After the harvesting procedure, the various anatomical planes were closed. They were first sutured together with the periosteum and left, with separate stitches, with a slowly reabsorbing suture thread (Vicryl 3/0: practically no reabsorption in the first 30 days, then gradual between the 60th and 90th day).

Onlay and inlay grafts

It was essential to correctly manipulate the graft during the apposition procedures (36). One of the main problems of these procedures was to limit the dehydration of the harvested bone while waiting for fixation. For this reason, the graft was stored in a container containing blood taken from the patient mixed with cooled saline as recommended by several authors (37). The action of two surgical teams that acted simultaneously on the donor site and the recipient site allowed a rapid transplant, with very high cell survival.

In correspondence with the residual alveolar crest, a full-thickness incision was performed that extended (in cases of total edentulism) from the right maxillary tuberosity to the left maxillary tuberosity; in cases of partial edentulism,

the incision was limited by the presence of the dental elements and continued with intra-sulcular incisions in order to optimally expose the operating field or by using releasing incisions.

The recipient site was prepared by eliminating any residual connective tissue and inflammatory tissue from the residual crest; it was subsequently regularized by removing or rounding off any gross irregularities. The recipient bone was bloodied and some perforations were made that allowed an early blood supply, in such a way as to favor a rapid neo-angiogenesis.

The key to the engraftment of the graft is its complete immobilization at the recipient site. A rigid fixation allows to reduce or eliminate the microtraumas between the grafted bone and the recipient site, which would lead to the formation of connective tissue in their interface with consequent increase in reabsorption and impediment of an optimal engraftment. For the stabilization of the grafts, osteosynthesis screws with a diameter of 2 mm were used.

When the maxillary atrophy also involved the posterior sectors, where the problem in addition to bone resorption was hyper-pneumatization of the maxillary sinus, large maxillary sinus lifts were performed (38).

The entire procedure was performed using piezoelectric technology (39). The surgical protocol began with the access antrostomy that was performed according to Caldwell-Luc on the vestibular wall of the sinus using piezoelectric osteotomy of the bone window.

The most frequent cause of graft failure is to be found in the infection of the same caused by the exposure of the grafted bone in the maxilla due to a dehiscence of the suture of the surgical wound. For this reason, the hermetic closure of the flap, with adequate coverage of the bone graft represents the most important surgical step to obtain the graft's engraftment. An early dehiscence of the surgical wound inevitably exposes the grafted bone to bacterial contamination with consequent very high risk of infection of the same which leads to its almost total loss, or partial in those "lucky" cases in which the antibiotic therapy immediately started, local and general, and the re-execution of the suture manage to dominate the infectious picture.

Post-operative management

All patients were treated with antibiotics and non-steroidal analgesics in the post-operative period. Patients were also advised to follow a soft diet for two weeks and use an antiseptic mouthwash (chlorhexidine 0.12%) for home control of bacterial plaque. After a healing period of 7 days, necessary for the stabilization of the wound, the sutures were removed. During the entire period of graft attachment, patients were advised not to place any mobile prosthetic device to avoid complications such as exposure of the grafts, infections and loss of the same.

Implant surgery

After a waiting period of 4-5 months, necessary for the consolidation of the graft, a second surgical intervention was performed for the removal of the osteosynthesis screws and the insertion of the implants (two-stage method). This second intervention was appropriately planned by performing the same tests and evaluations performed initially on the patient: OPT, CT and study of the models to evaluate the success of the grafts.

Plexus infiltration anesthesia was performed using mepivacaine with adrenaline 1:100000. Subsequently, the access flap and full-thickness mucoperiosteal tissue detachment were performed. The access flap included a linear incision at the center of the crest, associated with possible release incisions especially when the flap was limited by the presence of dental elements. The distal extension of the crestal incision depended on the number and position of the planned implants. The osteosynthesis screws were removed and the stability of the grafts was verified; the implant site was prepared taking into account that the grafted bone had a quality comparable to a class IV according to Leckholm and Zarb.

The crest was slightly flattened and regularized with a 4-5 mm diameter rosette bur mounted on a straight handpiece and with abundant irrigation of sterile saline solution.

In the protocol used, it was chosen to under-prepare the site to take advantage of the compaction given by the implant that allowed to obtain a larger contact surface and to obtain primary stability more easily. The implants were inserted by means of a surgical handpiece at low speed (15-20 rpm) and controlled torque (43 Ncm). After the removal of the mounting systems, the closing screws were positioned that allowed to seal the internal cavity of the implant. The flap was repositioned without tension, to avoid the uncovering of the implants during the osseointegration phase. The suture was done by means of single and continuous stitches with 3/0 silk thread.

Clinical case

Number 13, a 58-year-old female patient, presented for observation at the dental clinic of the University of Milan-Bicocca requesting implant-prosthetic rehabilitation of the stomatognathic system (Fig. 1-8).

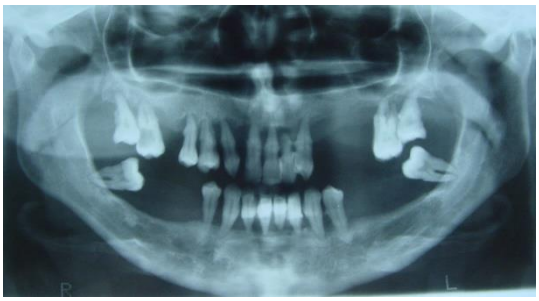

Fig. 1. *Initial radiological picture.*

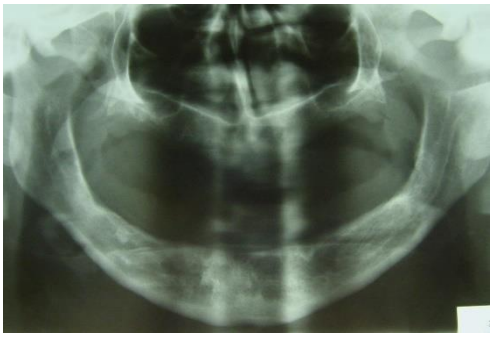

Fig. 2. *T_0 - pre-operative OPT, 60 days after teeth extraction.*

Fig. 3. *Iliac harvest.*

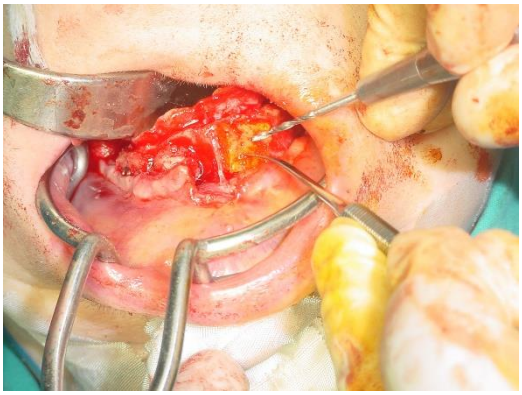

Fig. 4. *Fixation of the bone graft at the maxillary level.*

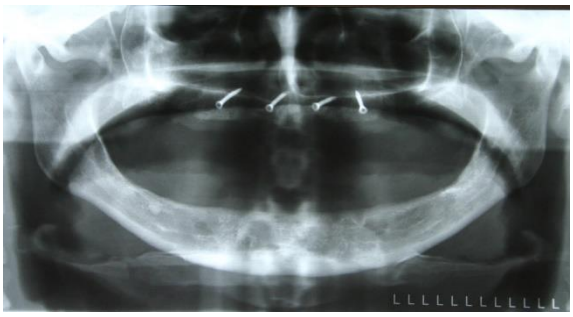

Fig. 5. *T_1 - OPT after apposition of bone grafts.*

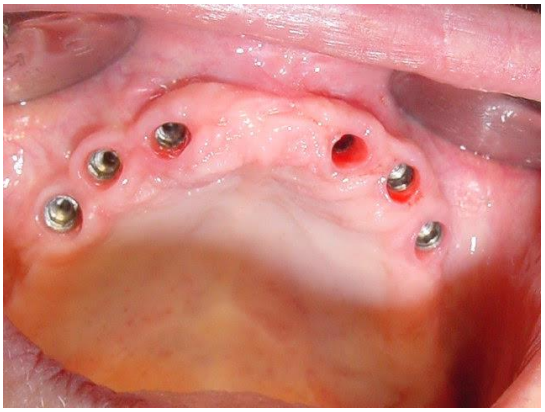

Fig. 6. *Insertion of the fixtures.*

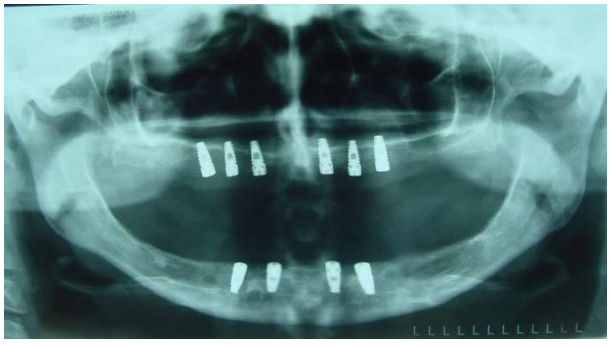

Fig. 7. *T_2 - control OPT.*

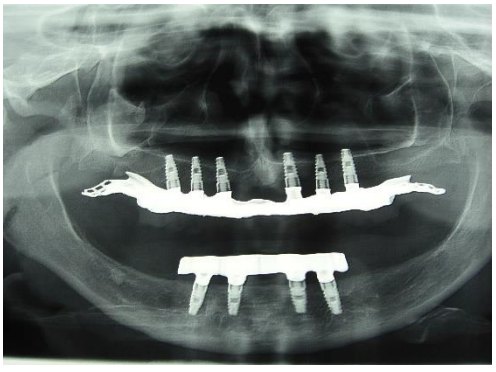

Fig. 8. *T_3 - control OPT.*

RESULTS

Tables I-VIII summarize the results of the investigation.

Table I. *Summary table of interventions.*

P	Age	Gender	Type of intervention
1	56	M	Upper jaw: onlay
2	52	M	Upper jaw: onlay + bilateral sinus lift
3	47	F	Upper jaw: onlay
4	62	M	Upper jaw: onlay
5	58	F	Upper jaw: onlay + bilateral sinus lift
6	53	M	Upper jaw: onlay + monolateral sinus lift
7	51	F	Upper jaw: onlay + monolateral sinus lift
8	48	M	Upper jaw: onlay + bilateral sinus lift
9	60	F	Upper jaw: onlay + bilateral sinus lift
10	59	M	Upper jaw: onlay + bilateral sinus lift
11	49	F	Upper jaw: onlay + bilateral sinus lift
12	62	F	Upper jaw: onlay + bilateral sinus lift
13	58	F	Upper jaw: onlay
14	49	F	Upper jaw: onlay + bilateral sinus lift
15	55	F	Upper jaw: onlay + bilateral sinus lift

The timing of the graft evaluations was as follows: T_0 (pre-operative situation), T_1 (post-operative situation) and T_2 (situation 4-5 months after surgery at the time of implant placement).

Table II. *Evaluation over time of the overall height of the bone crests.*

T	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15
T_0	5.9	3.8	4.7	2.3	3.4	4.1	4.9	4.2	3.8	6.1	4.2	4.6	3.8	4.3	2.9
T_1	13.2	12.7	12.2	13.1	12.9	13.1	14.2	13.5	12.7	13.4	12.4	12.8	13.1	13.7	11.8
T_2	12.1	10.7	11.1	//	11	12.4	11.8	11.6	10.1	11.6	11.1	11.7	10.9	11.8	10.2

Table III. *Evaluation of the overall thickness of the bone crests over time.*

T	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15
T_0	2.5	3.6	4.1	3.4	3.1	2.9	4.1	3.9	3.8	2.8	4.4	3.8	3.4	2.7	3.5
T_1	8.8	10.5	9.7	10.9	8.8	10.1	9.4	9.5	8.9	10.1	10.5	9.8	9.7	9.7	10.2
T_2	6.7	7.9	7.7	//	7.6	8	7.7	8.2	6.9	8	8.4	7.7	8.3	7.1	7.9

Table IV. *Evaluation of graft height resorption during creeping substitution.*

T	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15
T_1	7.3	8.9	7.5	10.8	9.5	9	9.3	9.3	8.9	7.3	8.2	8.2	9.3	9.4	8.9
T_2	6.2	6.9	6.4	//	7.6	8.3	6.9	7.4	6.3	5.5	6.9	7.1	7.1	7.5	7.3

Table V. *Evaluation of graft thickness resorption during creeping substitution.*

T	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15
T_1	6.3	6.9	5.6	7.5	5.7	7.2	5.3	5.6	5.1	5.1	6.1	6	6.3	7	6.7
T_2	4.2	4.3	3.6	//	4.5	5.1	3.6	4.3	3.1	3.1	4	3.9	4.9	4.4	4.4

Table VI shows the differences between the implants planned during the pre-operative study (X) and the fixtures actually positioned (Y) defining the impossibility of positioning the implant as a graft failure for that sector (Z).

Table VI. *Planned and positioned implants.*

	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15
X	4	5	4	6	8	2	2	8	10	6	6	6	6	10	8
Y	3	5	4	4	7	2	2	8	9	6	6	6	6	9	8
Z	1	0	0	2	1	0	0	0	1	0	0	0	0	1	0

Table VII shows the number of fixtures inserted (X) and the number of implants in which integration failed (Y) according to the parameters previously described.

Table VII. *Success of osseointegration of implants.*

	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15
X	3	5	4	4	7	2	2	8	9	6	6	6	6	9	8
Y	0	0	0	0	1	0	0	1	1	0	0	0	0	0	1

Table VIII shows the averages of the resorption measurements performed around the fixture (X) at reopening before prosthetic loading (T_3).

Table VIII. *Evaluation of peri-implant resorption.*

	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15
X	0.6	0.8	0.9	0.8	1.3	0.7	0.9	0.7	0.6	1.1	1.3	0.7	1.4	1.2	1

DISCUSSION

The postoperative course of the reconstructive surgical phase was uneventful in all patients examined, considering a difficult ambulation for 15-20 days after the bone harvesting procedure at the anterior iliac crest level as normal. Four patients reported pain for the first week after the harvesting procedure. The symptoms were controlled with oral anti-inflammatories and no patient had pain at the 10-day follow-up. Patient #4 presented a graft exposure after 48 hours from insertion and this caused the loss of the *onlay* graft in the third sextant but not in the first or second. This complication determined the surgical failure for that sector and consequently the failure of the graft for the positioning of 2 fixtures.

All the other grafts showed a positive response to all the criteria proposed by the study including bleeding from the sites where the osteosynthesis screws were extracted, determining the success of the grafts. Radiographic and clinical measurements of the grafts demonstrated an average resorption due to the phenomena inherent to the graft engraftment of 28.5% in height and 31.3% in thickness. This phenomenon has been defined in the literature as unpredictable (40). The values detected are however compatible with the literature: Verhoven (41) analyzed the percentage of bone resorption of autologous grafts detecting values between 25% and 36% at the end of the engraftment period. Of the 91 implants planned in the diagnostic phase, 85 (94%) were inserted satisfying the prosthetic criteria and obtaining in all cases a satisfactory primary stability defining the success of the three-dimensional rehabilitation of that sector.

At T_3 (reopening before prosthetic loading) the failure of the integration was detected of 1 implant in patient #5, of 1 implant in patient #8, of 1 implant in patient #9 and of 1 implant in patient #15. The prosthetic treatment plan underwent, in these patients, some changes that did not, however, contraindicate the use of implant-supported prostheses. The percentage of implants inserted and satisfying the established criteria was 96%. These results are also compatible with data provided by the literature.

In a study, Sjostrom (42) presented an integration percentage at 6 months of 91%. In 2009, Kamal (43) described the results obtained from implant rehabilitation of severely atrophic maxillae reconstructed by means of apposition bone grafts, at 6 months from placement, with percentages of 95%. Clayman (44) also showed a similar percentage but in a more limited study with the insertion of 41 implants. Keler (45) analyzing 32 patients reconstructed with apposition bone grafts at the level of the upper maxilla presented an integration before prosthetic loading of 91%. Chiapasco (46), in 2007, published a 6-month success rate of 98.5%. Thor (47) from 2000 to 2005, analyzed 19 patients reconstructed with autologous bone grafts of apposition at the level of the upper maxilla (for a total of 152 implants positioned), reporting a preload percentage of 98%. Six months after insertion and before loading, Barone (48), had a success rate of 96%.

In 2003, a study was conducted by Reinert (49), in which 30 patients were considered who underwent maxillary reconstruction with iliac crest harvesting. The success of integration before prosthetic loading was 96.5%. The measurement of marginal peri-implant resorption in 13 showed average values between 0.6 and 1.4 mm with an overall average of 0.9 mm. Also Barone and Covani (48) in a 2007 study highlighted a reabsorption in a range between 0 and 1.6 mm.

CONCLUSIONS

The aim of this work was to evaluate the success of the treatment of severe atrophy with autologous bone grafts and the clinical success of implantology before prosthetic loading. In relation to the criteria taken into consideration, we obtained a 94% success in the three-dimensional rehabilitation of the upper jaw that allowed a prosthetically guided insertion of 85 implant fixtures. Morbidity was low in all treated cases and the limited complications were easily managed. A bone resorption during creeping substitution compatible with the international literature was highlighted. The values of bone resorption before implant insertion and its prosthetic loading are however a variable that cannot be predicted from patient to patient. Therefore, as suggested by several authors, in each intervention an overcorrection of the atrophy or bone defect was performed by means of an "oversized" graft that still allowed us to obtain a bone crest that reflected the requirements necessary for implantology.

The unpredictability of resorption, in accordance with most scientific works, has suggested to undertake the surgical phase of insertion of endosseous implants 4-5 months after the reconstructive surgical phase (two-stage procedure, with deferred implants); subsequently, before starting the prosthetic loading of the implants, it was necessary to wait 6 months to ensure the integration of the same implants at the level of the "grafted" sites. During this period, 96% of the implants positioned demonstrated clinical success and limited resorption (average of 0.9 mm). In literature, it has been shown that this is the period with the highest implant failures (early failure - before loading) compared to failures after loading (late failure). The data collected and these considerations allow us to affirm that the procedure evaluated for the management of severe bone atrophy allows us to obtain, after the grafts have taken root, a situation completely similar to a class II jaw according to Cawood and Howell with compatible implant results. One can recognize the success of the therapy in atrophic maxillae reconstructed by means of autologous apposition bone grafts.

The future purpose will be to evaluate implant success after 1 prosthetic load according to Albrektsson criteria with a significant follow-up while expanding the patient sample.

Conflicts of interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contribution

All the authors equally contributed to the manuscript and read and approved the final version of the manuscript.

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Evaluation Study

A HISTOLOGIC EVALUATION OF FAILED DENTAL IMPLANTS FOR OVERLOADING

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ABSTRACT

Osseointegrated implants have shown excellent clinical results, demonstrating their effectiveness in various medical applications. However, it is important to note that about 3-10% of these implants fail within a 10-year period. This highlights the need to understand the histologic response to reduce the incidence of implant loss over time. The aim of the present study was a histological analysis of the features of the tissues surrounding implant-failed titanium implants to try to understand the causal determinants. Dental titanium screw-shaped implants were removed for mobility. The implant had been placed in the jaw three months earlier. The implant was retrieved with a trephine. In the most coronal and apical parts of the implants, no mineralized tissues were present in contact with the dental implant. At low magnification, bone was observed at 200µ distance to the implant. In conclusion, the histological aspect of the dental implant suggests that overload may be the most likely cause of failure in the present case. However, we cannot be certain that it is the only possible cause in every case.

KEYWORDS: *bone physiology, bone overheating, implant failure, dental implants*

INTRODUCTION

Osseointegrated implants have shown excellent clinical results, demonstrating their effectiveness in various medical applications. However, it is important to note that about 3-10% of these implants fail within a 10-year period (1). This highlights the need to understand the histologic response to reduce the incidence of implant loss over time.

It is critical to investigate the factors that contribute to implant failure. With a deeper understanding of these causes, we can improve the clinical performance and longevity of osseointegrated implants. This research is essential for developing strategies to minimize implant loss and improve implant survival. The placement of an implant invariably triggers an inflammatory response due to the surgical trauma involved. This initial inflammation is a natural part of the bone healing process, aimed at protecting the affected area and beginning bone repair. Nevertheless, managing this response effectively is important to ensure successful osseointegration and long-term stability of the implant. The persistence or reduction of a reaction to an implant is influenced by several factors, including the material used, the implantation site, and the mechanical

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loads applied. When a dental implant is inserted into bone tissues, an equilibrium must be established. This balance is crucial as the interactions between the implant and the surrounding tissues will dictate the subsequent development of these tissues around the biomaterial. In essence, these interactions determine the type of tissue, bone or fibrotic tissue, that will form around an implant.

The material of the implant plays a pivotal role in this process. Biocompatible materials like titanium are generally more favorable as they elicit a less severe immune response. Also, atraumatic surgery plays a crucial role in this process. The implantation site is also important; areas with rich blood supply and robust tissue structures are more likely to support healing. Additionally, the loads or stresses on the implant can affect its stability and the body's response, especially in the first healing phase. In the mandible, the most commonly observed bone type associated with implant failures is Type I bone (2). In jaws with high bone density, the overheating of the surgical site due to inadequate irrigation or blockage of the bur's internal irrigation by bone chips may determine a failure during healing (3). The importance of meticulously managing frictional heat through precise surgical techniques with the new drills has been emphasized (4). The aim of the present study was a histological analysis of the features of the tissues surrounding the failed titanium implant to try to understand the causal determinants.

MATERIALS AND METHODS

Dental titanium screw-shaped implants were removed for mobility. The implant had been placed in the jaw three months earlier. The implant was retrieved with a trephine. After removal, the specimen was immediately fixed in neutral buffered formalin to preserve its structure and prevent degradation. This fixation process is crucial for maintaining the integrity of the tissues for further analysis. The specimens were then processed using the "Precise 1 Automated System" (Assing, Montesilvano, Italy), which ensures precise sectioning of the sample.

Following fixation, the specimens underwent dehydration through a series of alcohol rinses. This step gradually removes water from the tissues, preparing them for embedding. The dehydrated specimens were then embedded in glycolmethacrylate resin. This resin provides a stable medium that supports the tissue structure during sectioning.

The embedded specimens were sectioned using a high-precision diamond disc, initially cut to a thickness of approximately 150 μm. These sections were then ground down to about 30 μm, creating thin slices suitable for microscopic examination. Three sections were cut for implant in a way parallel to the major axis. The microscope was equipped with a video camera, which was used to capture detailed images of the slides. These images are essential for documenting the findings and for further analysis.

RESULTS

After staining, the slides were examined under normal transmitted light using a Nikon microscope. This microscopy technique allows light to pass through the specimen, providing a clear view of the stained tissues.

In the most coronal and apical parts of the implants, no mineralized tissues were present in contact with the dental implant. At low magnification, bone was observed at 200μ distance to the implant (Fig. 1). At higher magnification, no osteoblasts were visible around the dental implant. No bacteria were observed (Fig. 2). No necrotic bone or partially demineralized was present. No pathological infiltration cells were observed in soft tissues.

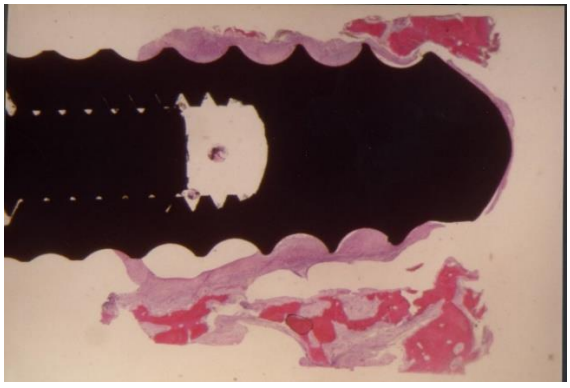

Fig. 1. *No mineralized tissues were present in contact with the implant. At low magnification, bone was observed at 200μ distance to the implant. At higher magnification, no osteoblasts were visible around dental implant. No bacterial was observed. Blue di toluidine and acid fuschin12x.*

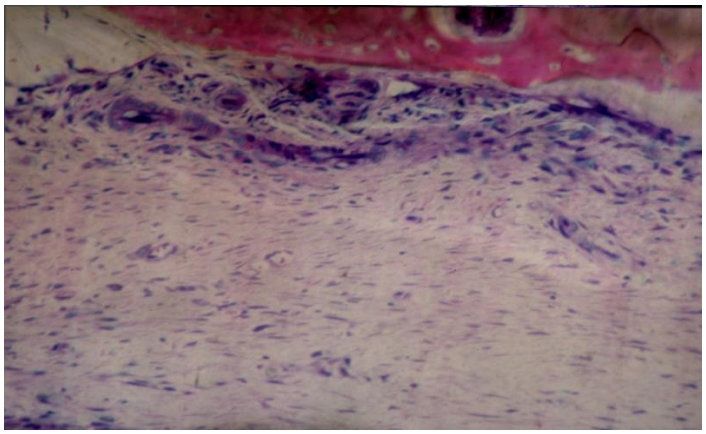

Fig. 2. *No bone necrosis was observed. Blue di toluidine and acid fuschin12x.*

DISCUSSION

Implant failure is a multifaceted issue influenced by various factors, including patient health, surgical technique, and implant characteristics (5). Common causes include lack of primary stability, poor bone quality, surgical trauma, and infection (6, 7). Specific risk factors identified include using proton pump inhibitors (PPIs), which may disrupt osseointegration (8). Early implant failure occurs before the prosthesis is delivered or within the first year of loading, often due to issues with osseointegration or surgical trauma (9). Late implant failure, occurring after one year of loading, is frequently associated with occlusal overload and biomechanical factors (10).

Research has shown that early failures are more common in the maxilla due to lower bone density, while late failures are linked to factors such as excessive loading and poor implant design. Patient health significantly impacts implant success. Conditions such as diabetes, osteoporosis, and chronic periodontitis increase the risk of implant failure (11). Smoking is another critical factor, with smokers exhibiting higher rates of marginal bone loss and implant failure compared to non-smokers (12). Additionally, a history of failed endodontic treatment at the implant site has been associated with higher failure rates (13). Also, the location of the implant plays an important role in its success. Bone quality and volume at the implant site are critical determinants of implant stability and success. Implants placed in the maxilla, particularly the anterior region, have higher failure rates due to lower bone density compared to the mandible (9). Treated implant surfaces have been shown to reduce failure rates compared to machined implants, likely due to improved osseointegration (14).

In our case, we observed soft tissue around the dental implant without pathological infiltration of inflammatory cells. This histological aspect may be due to:

a) a premature loading of the implant;
b) an apical migration of epithelium;
c) too much torque during implant placement;
d) a gap between the implant and bone site.

According to Chatzopoulos et al. (13), the major cause of implant failures is biomechanical overloading. Overloading is an important cause of implant failure (15), and research affirms that failure to obtain a tight bone-implant contact may be related to the use of unsuitable materials, traumatic surgery, and too-early implant loading. An important factor in avoiding bone overheating and dental failure is the use of minimally traumatic surgery with a careful surgical protocol and copious saline irrigation during drilling. It has been described that a 47°C exposure for 1 minute is sufficient to cause bone necrosis and that the temperature of no return for bone is around 60°C for 1 minute.

CONCLUSIONS

In conclusion, the histological aspect of the dental implant suggests that overload may be the most likely cause of failure in the present case. However, we cannot be certain that it is the only possible cause in every case. This is evidenced by the absence of necrotic bone, resorption lacunae, and the absence of osteocytes, presence of soft tissues, which indicate excessive stress on the implant. However, it is important to acknowledge that other factors could also contribute to implant failure. These may include biological factors such as infection, improper surgical technique, or patient-specific conditions like

poor bone quality or systemic health issues. Therefore, while overload appears to be the most probable cause, it is essential to consider a comprehensive evaluation of each case to identify all potential contributing factors to ensure successful implant outcomes.

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Clinical Trial

SAFETY AND EFFICACY OF THE " RIALTO" TECHNIQUE: AN EXPLORATIVE TRIAL

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ABSTRACT

A series of patients were treated with the "Rialto" maxillary sinus lift technique. The primary aim of the present study is to evaluate the percentage of intraoperative complications such as perforation of the sinus mucosa and benign paroxysmal positional vertigo (BPPV). The second aim is to assess bone regeneration within the maxillary sinus with the sole use of collagen and clotting after 9-24 months of prosthetic loading. Twenty patients, 8 females and 12 males aged between 20 and 72 years participated in this study, treated consecutively from 2019 to 2021 with the "Rialto" surgical technique to obtain transcrestal maxillary sinus lift and simultaneous implant positioning. Nine implants with Ø 4x 9 mm (Neoss straight, Neoss Ltd, Arrogate, UK) n. 6 BTK evo Ø 4x 10 mm and n. 5 BTK safe Ø 3.7 x 10 mm [Biotec srl Povolaro di Dueville (VI)] Italy The implants were allowed to heal for 4 months before the second surgery. Osseointegration was evident in all 20 patients. The median vertical bone height (VBH) values increased significantly between the first surgery (median 6 mm; 25th-75th percentile, 5 mm-6 mm) and the follow-up (median 9 mm; 25°-75th percentile, 8 mm-9 mm). No case of rupture of the sinus mucosa was detected. No patient complained of benign paroxysmal positional vertigo. The transveolar approach using the "Rialto" technique provides high predictability for elevating the maxillary sinus floor. The method, which has minimally invasive characteristics, reduces the most common complications, such as perforation of the sinus mucosa and BPPV.

KEYWORDS: *maxillary sinus, minimally invasive, dental implants, sinus floor augmentation, bone regeneration, osseointegration*

INTRODUCTION

The combination of post-extraction crest resorption and maxillary sinus pneumatization often limits the available bone height for implant placement in the posterior maxilla, requiring a regenerative procedure known as maxillary sinus lift. The maxillary sinus lift procedure, with a lateral approach or a transcrestal approach, is surgical techniques that allow for the restoration of adequate vertical bone volume and, in some cases, simultaneous implant placement. Both lateral (1) and transcrestal approaches are widely used and have shown a high success rate (2). The selection criteria between these two techniques are based on residual bone height (RBH), calculated as the distance from the maxillary sinus floor to the

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crestal bone. The Sinus Consensus Conference in Boston (1996) and subsequent classifications have suggested the transcrestal approach with RBH of 6-7 mm and lateral window sinus lift in the presence of 5 mm or less of bone below the sinus floor (3). Today, with new minimally invasive techniques using a transcrestal approach, it is possible to perform sinus lift and simultaneous implant placement in sites with a residual bone height of ≤5 mm while maintaining an excellent implant survival rate (4-5).

Tatum in 1986 and later Summers in 1994 were the first to propose the transcrestal approach, which involved lifting the maxillary sinus membrane in the direction of the crest, using a kit of osteotomes with the possibility of inserting filling materials and the simultaneous placement of the implant (6-7). Although it is a valid alternative to the more invasive lateral window technique, the main disadvantage is the possibility of inadvertently causing small lacerations of membrane if the osteotomes penetrate the sinus without being able to highlight them since the maneuver is performed without visually monitoring the lifting of the membrane. Despite this limitation, membrane perforation is less frequent compared to the lateral window technique (8). In 1997, Engelke et al. performed the crestal technique under endoscopic control, observing that the membrane could be lifted to 5 mm without the risk of perforation (9). In a multicentric study, Rosen et al. placed 174 implants in 101 patients using the "osteotome technique". After a loading period of 6 to 66 months, they achieved a success rate of 96% when the remaining bone height was ≥ 5 mm, whereas the percentage decreased to 85.7% with a residual bone height ≤ 4 mm (10). A retrospective study of 430 patients undergoing crestal maxillary sinus lift in sites with RBH ≤ 5mm obtained 12 early failures, with 7.2% perforations and 0.5% benign paroxysmal vertigo. An interesting finding in this study is that they received an incidence of 1.1% perforations in sinuses with a narrow palatal-vestibular distance ≤ 12mm, while the incidence increased to 16.1% in wide sinuses (11).

An additional complication with osteotomes is benign paroxysmal positional vertigo (BPPV), with an incidence reported in the literature between 1.25% and 3.06%. It is an otoneurological disorder, and its pathogenesis has been attributed to the detachment of otoliths from the utricular macula and their displacement to the semicircular canals during the basal cortical fracture maneuver of the maxillary sinus using osteotomes (12). Currently, the need for simultaneous bone grafting after maxillary sinus floor elevation is still controversial.

The possibility of new bone formation with the only elevation of the maxillary sinus membrane has been observed in studies on humans and animals (13-14). Lundgren et al. described a new technique reporting 100% success in implant survival and bone regeneration after 9 months of function in 12 sinus lifts performed on 10 patients. The technique involves the creation of a lateral window, removing it, lifting the sinus mucosa, implant insertion, and subsequently repositioning the bone window itself. The authors have demonstrated that the elevation of the mucosa and the creation of an empty space in which blood clots form determine the formation of new bone tissue (15). The transcrestal sinus lift procedure mediated by osteotome can be performed with or without using bone grafting material such as allograft, autologous bone, or heterologous bone material. No significant differences in implant survival and success rates have been observed when comparing the two methods (16).

Pjetursson et al. radiologically evaluated bone remodeling after inserting 252 implants using the crestal technique with and without filling materials. The authors conclude that, without using graft material, only a moderate increase in bone around the implant circumference can be observed; in contrast, a substantial bone increase was radiographically observed with the use of graft material (17). The main purpose of this study is to evaluate the percentage of intraoperative complications such as sinus membrane perforation and benign paroxysmal positional vertigo. The second purpose is to assess bone regeneration within the maxillary sinus using only collagen and clotting after 9-24 months of prosthetic loading using the Rialto Technique.

MATERIALS AND METHODS

Twenty patients participated in this study consecutively treated from 2019 to 2021 with the "Rialto" surgical technique to obtain transcrestal maxillary sinus lift and simultaneous implant placement. A total of 9 implants of 4x9 mm (Neoss straight, Neoss Ltd, Arrogate, UK), 6 BTK Evo of 4x10 mm, and 5 BTK Safe of 3.7x10 mm [Biotec srl Povolaro di Dueville (VI) Italy] were inserted. All sinus lifts were performed by an experienced operator. The study was approved by the local ethics committee (Ethics Committee Lazio, Rome Italy Prot.739/CE).

The inclusion criteria were:

I. premolar and molar edentulous area;
II. presence of residual bone below the maxillary sinus of ≥ 5 mm where the implant was planned;
III. the implant should not be inserted more than 5 mm into the maxillary sinus;
IV. perfectly healed bone crest (at least 4 months must have passed since tooth extraction);
V. age > 18 years;

VI. absence of endodontic lesions in neighboring teeth;
VII. ability to understand the informed consent and signature of the same.

The exclusion criteria were:

I. absolute contraindications to implant therapy (Hwang & Whang, 2006);
II. irradiated head and/or neck;
III. uncontrolled diabetes;
IV. pregnancy;
V. heavy smoker > 20 cigarettes per day;
VI. poor oral hygiene;
VII. acute and chronic maxillary sinus diseases;
VIII. presence of sinus septa;
IX. "severe" periodontal disease.

Preoperative evaluation includes the execution of a periapical endoral X-ray with the Rinn technique and, if necessary, a Cone Beam. Before each procedure, patients were informed about any risks and provided their consent to treatment. Each patient underwent postoperative follow-up visits to detect or intercept any complications induced by the surgical procedure. The implants were allowed to heal for 4 months before the second surgery. The follow-up includes the execution of endoral radiographs in three different phases for all patients: 1) before surgery to calculate the residual bone height (VBH); 2) immediately after implant placement; and 3) at a prosthetic loading follow-up from 13 to 43 months. For measurements, a magnifying lens (x4.5, Carl Zeiss, Oberkochen, Germany) and a caliber were used (Fig. 1, 2).

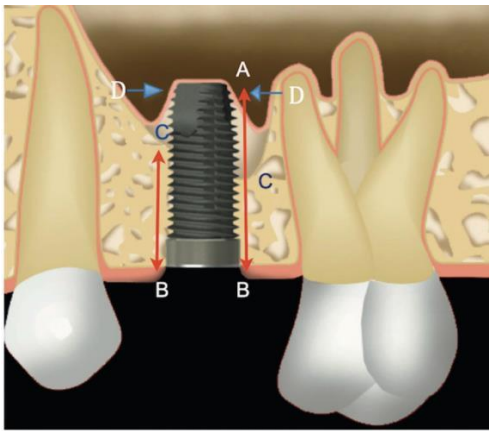

Fig. 1. ***A****: implant apex;* ***B****: cresta position of the implant platform;* ***C****: sinus bone cortical level before surgery;* ***D****: most apical point of the sinus mucosa (immediately after surgery).* ***B- C****: bone crestal height before surgery (RBH);* ***C-A****: length of the implant inside the sinus;* ***D****: most apical point of new bone regeneration in contact with the implant at follow-up;* ***D-C****: bone gain within the sinus.*

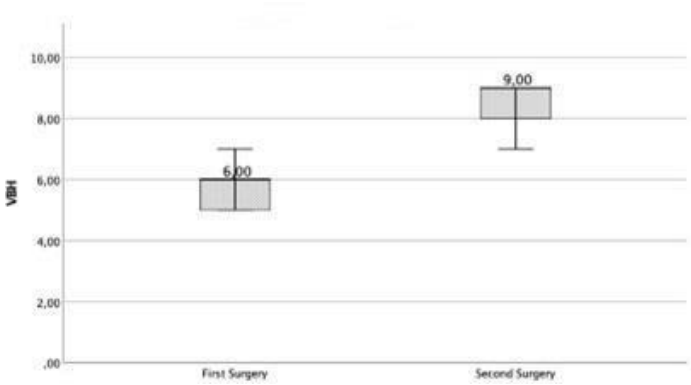

Fig. 2. *VBH at first and second surgery.*

Surgical and prosthetic procedure

Before the surgery, all patients were prescribed pharmacological therapy (Amoxicillin, Sandoz AS, Copenhagen, Denmark, 1gr. X 2 for 5 days) and anti-inflammatory medication (Ibuprofen, B. Braun Melsungen AG, Germany, 400 mg) 2 tablets X 2 times a day. Under local anesthesia (Mepivacaine 2%, Saint-Maur-des-Fosses, France), the implant site preparation was performed according to the standardized sequence of drills and manual instruments of the Rialto procedure as described below. The implant socket is prepared with a sequence of helical drills (HS) with increasing diameter (Ø 2.0 - 2.60 - 3.0 mm) up to 1 mm from the cortical of the maxillary sinus. To work safely, HS drill stops are used. (Fig.3a-d). The preparation continues using "Multicutting" drills with Ø 3.20, increasing the working depth (with

sinus lift drill stop) by 1 mm for each step until completely eroding the cortical below the mucosa. A rotational speed not exceeding 500 rpm is recommended. In addition to not damaging the sinus mucosa, the special feature of these drills is that they collect bone during drilling (Fig. 4).

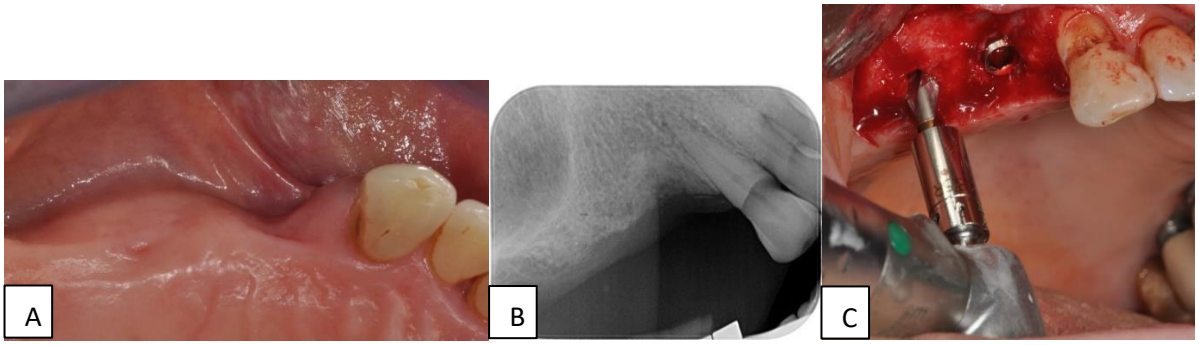

Fig. 3. ***A)****: Occlusal view of the edentulous area, note the osteo mucosal vestibular depression at the level of 14;* ***B)****: Initial Rx. Because of the edentulous area, the standardized placement with Rinn technique wasn't allowed.* ***C)****: Use of HS helical drill sequence with depth stop.*

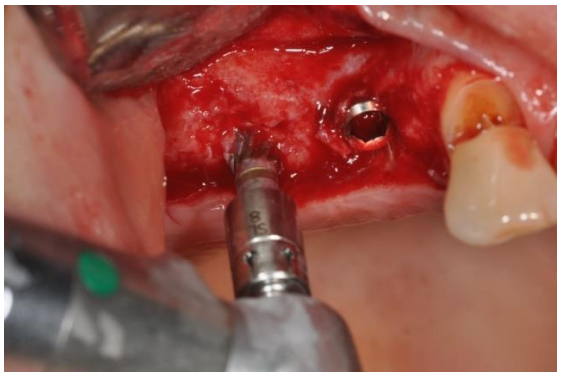

Fig. 4. *Use of a multi-cutter drill with a diameter of 3.2 mm.*

The manual tools "Sinus Lift" in the Rialto kit are used for the delicate next step, detachment and elevation of the sinus membrane. The internal and external 60° elevator has the function of detaching the membrane from the floor of the maxillary sinus (Fig. 5) while gently lifting the membrane continues with the rounded elevator of Ø 2.4 mm with a collagen sponge in between (Condress, Smith & Nephew, Agrate Brianza, Italy). This procedure can be repeated several times until the desired membrane elevation is achieved (Fig. 6).

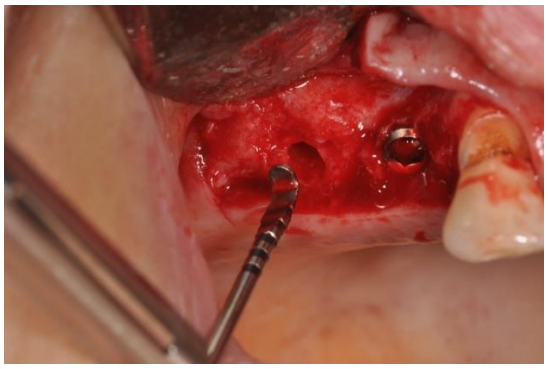

Fig. 5. *Initial detachment of the sinus mucosa with sinus lift (external and internal 60°) device.*

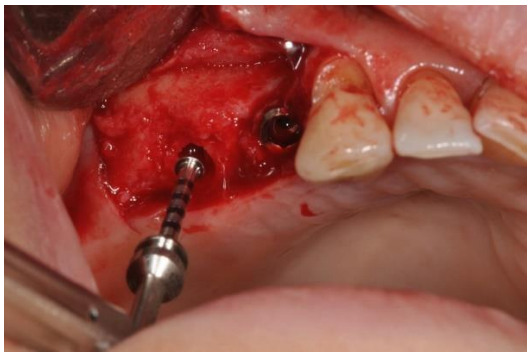

Fig. 6. *Sinus elevation using 2.4mm rounded sinus lift with collagen membrane interposition.*

In the presence of D1-D2 bone density, an additional drill from the system with a larger diameter than the last drill used for lower-density bone should be done before implant placement. A drill stop 1 mm below the sinus mucosa is recommended to rectify the socket preparation. The surgical procedure ends with implant placement, cover screw, and flap suturing with Supramid (B-Braun Surgical, S.A. Rubi Spain) 4.0 (Fig. 7a-b).

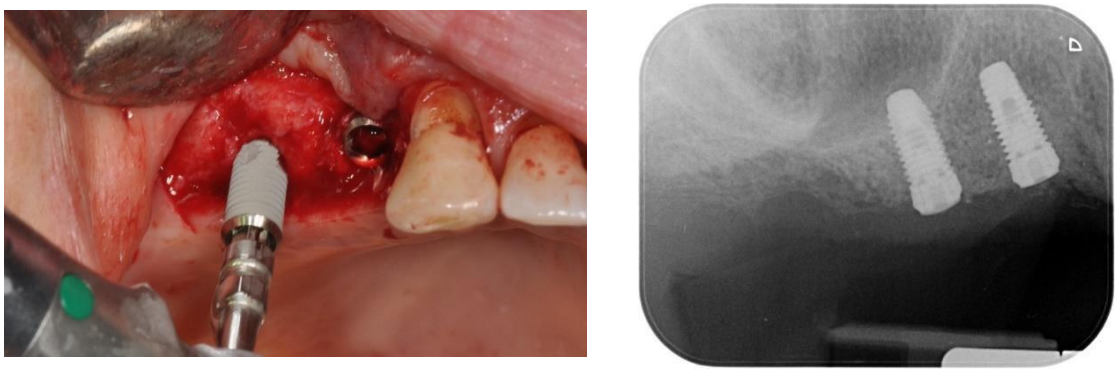

Fig. 7. ***A****): Implant placement;* ***B****): Immediate implant placement revealed a slight radiopacity at the apex of the implant caused by collagen-sponge.*

The presence of any perforation of the sinus mucosa was evaluated with the Valsalva maneuver at each step of the procedure. All patients were advised to return after 10 days to remove the sutures and assess healing. Patients were followed up every 6-8 weeks, and any adverse events were recorded. After 4 months from the first surgical phase, the implants were uncovered, and a healing screw was inserted. In the case presented to correct the vestibular mucosal defect in zone 1.4, we performed a mucosal graft taken from the left tuberosity (Fig. 8).

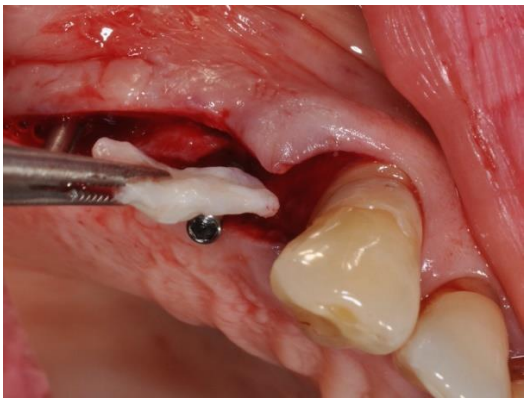

Fig. 8. *Use of a connective tissue graft taken from the tuberosity to relieve the vestibular bone defect in zone 14.*

We opted to insert two slim abutments (Fig. 9, 10) to facilitate wound healing. After about three weeks, they were replaced with standard healing screws (Fig. 11a, b).

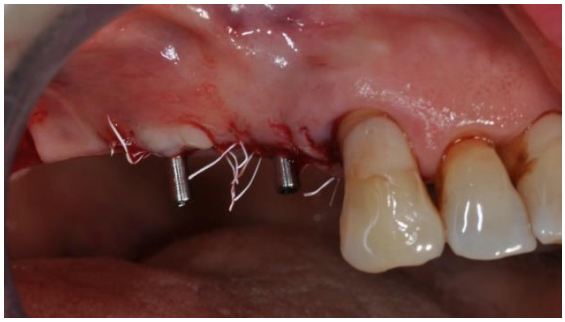

Fig. 9. *Slim abutments placement and suture.*

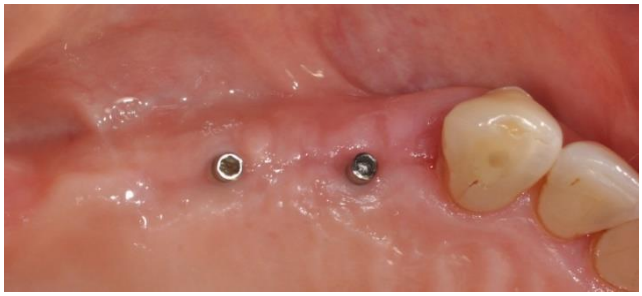

Fig. 10. *Tissue healing after four weeks.*

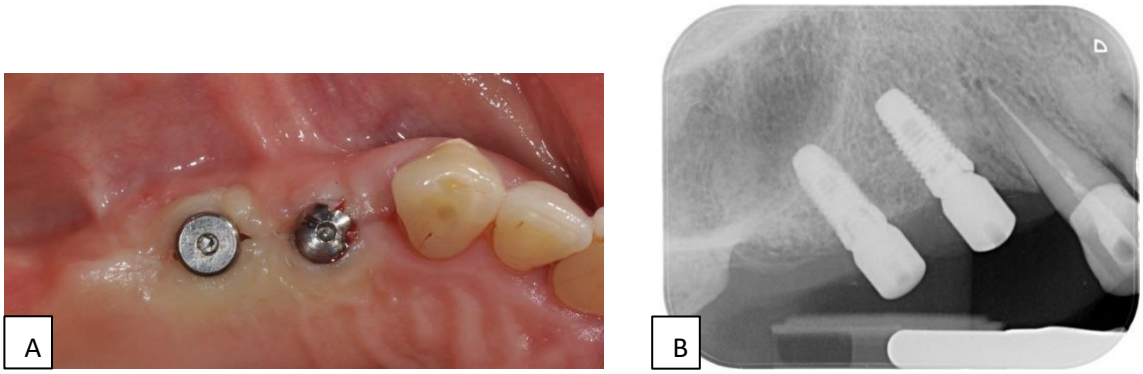

Fig. 11. ***A****): replacement of slim abutment with larger diameter abutments;* ***B****): follow-up X-ray, bone regeneration with new sinus cortical position can be seen.*

Subsequently, a conventional impression was taken to fabricate metal-ceramic crowns (Fig.12a, b). At a follow-up ranging from 13 to 43 months, all patients were recalled for a control X-ray (Fig. 13). The primary outcome of the effectiveness of the Rialto technique was considered to be the bone gain within the maxillary sinus between the initial surgery and the 13-43 month follow-up (obtained as the difference between the VBH values measured between the initial surgery and the 13-43 month follow-up). The number of sinus mucosa perforations was considered the primary safety outcome, and the incidence of benign paroxysmal positional vertigo (BPPV) was regarded as the secondary safety outcome.

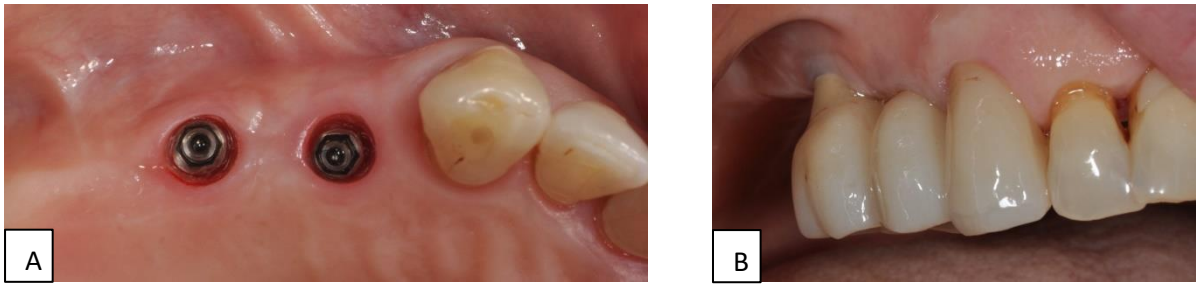

Fig. 12. ***A****): occlusal view of the mucosal pathway and the increase in soft tissue at the vestibular level of 14;* ***B****): appearance of the final prosthesis on delivery.*

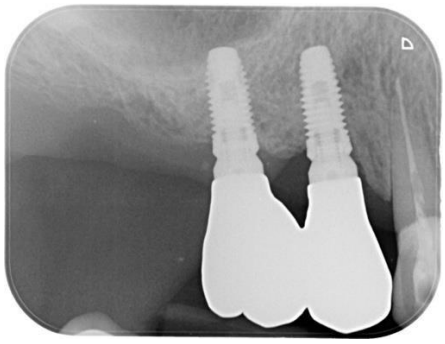

Fig. 13. *Follow-up X-ray at 16 months.*

In the descriptive statistical analysis, continuous quantitative variables were summarized using mean and standard deviation. Where the mean was not representative of the distribution, with the median and the 25th and 75th percentiles, categorical variables were summarized using absolute frequencies and percentages. Differences between median values at different time points were tested using the non-parametric Wilcoxon test. The level of statistical significance was set at alpha <0.05. The statistical analysis was conducted using the IBM Statistical Package for Social Science (SPSS) software version 25.

RESULTS

In this exploratory study, 20 patients with a median age of 64 years (25th-75th percentile, 20 years-72 years) were recruited, with 8 (40%) female patients and 12 (60%) male patients.

Efficacy

The median values of vertical bone height (VBH) significantly increased between the first surgery (median 6 mm; 25th-75th percentile, 5 mm - 6 mm) and the follow-up period, which lasted from 13 to 43 months (median 9 mm; 25th-75th percentile, 8 mm - 9 mm). Median bone gain at follow-up was 3 mm (25th-75th percentile, 2 mm - 3 mm) (Wilcoxon rank-sum test: Z=-3.985, p<0.001).

Safety

No cases of sinus membrane perforations were detected. No patients reported benign paroxysmal positional vertigo (BPPV).

DISCUSSION

The transcrestal technique using osteotomies, like any other surgical procedure, has undergone modifications to achieve greater simplicity, higher success rates, fewer complications, and less discomfort for the patient. The initial changes were planned to accelerate the procedure, simplify the fracture of the sinus floor cortical bone, avoid the use of a mallet, and minimize the percentage of sinus membrane injuries (18-50).

In this study, we evaluated bone regeneration within the maxillary sinus using only a blood clot and collagen sheets in 20 transcrestal sinus lifts performed on 20 patients using the atraumatic "Rialto" technique. We also assessed the most common intraoperative complications associated with the use of osteotomies, such as sinus membrane perforation and BPPV (19).

The height of the initial bone crest (RBH) is essential for both implant survival and the percentage of membrane perforations. Many authors consider a residual bone height of at least 4-5 mm as a clinical indication for the transcrestal technique (20). A review based on 19 studies using the osteotome technique demonstrated a survival rate of 95% after 5 years. However, the most significant difference was observed between implants placed in residual bone height (RBH) <5 mm, which showed a survival rate of 92%, compared to 96% for implants placed in bone with a height ≥5 mm. Furthermore, the authors concluded that using filling materials was irrelevant to implant survival (21). The results of our

study are consistent with the literature data, with a median bone regeneration of 3 mm (25th-75th percentile, 2 mm-3 mm) with RBH ≥5 mm and a 100% survival rate at a prosthetic follow-up ranging from 13 to 43 months.

Using a biomaterial inside the maxillary sinus with the crestal technique is still a subject of discussion. Studies comparing transcrestal sinus lift surgery with osteotomes with or without using bone graft materials and systematic literature reviews have not reported significant differences in implant survival and success rates (22, 23).

Nedir et al., in a study on 17 patients and 25 implants placed using the osteotome technique without filling material, reported an average bone regeneration inside the sinuses of 3.1 ± 1.5 mm and no implant failure after 3 years of prosthetic loading (24). Volpe et al. (25) observed no implant failures and an average increase in VBH of 2.8 ± 1.1 mm after 11-32 months of prosthetic loading in 29 implants placed in 20 patients. The subantral space created by elevating the Schneider membrane and supported by the implant fills with a stable clot that will mature to form new bone. The biological basis for the formation of new bone beneath the sinus mucosa follows the principles of bone regeneration, as occurs, for example, in healing in post-extraction sockets (26, 27). The blood clot induces the growth, proliferation, and differentiation of various types of cells, stimulating angiogenesis and new bone formation. The tent effect created by the implant beneath the mucosa triggers a process reminiscent of the principles of GBR (28, 29).

In 2006, Palma et al. (14) were the first to histologically demonstrate bone regeneration beneath the sinus mucosa supported by implants without filling materials. The authors concluded that the membrane plays a fundamental role in regeneration for its intrinsic properties and as a barrier protecting the clot.

However, in a subsequent study using the same animal model, it was observed that bone regeneration starts from the floor of the maxillary sinus. In contrast, it was not observed in conjunction with the sinus membrane after 10 days of healing (31). Scala et al. state that simultaneous implant placement plays a key role in bone regeneration within the maxillary sinuses when no filler is used. In a histological study on monkeys, they demonstrate that during the first 20 days following surgery, the sinus membrane does not participate in the regenerative process and that the input comes from the floor of the sinus and the bone chips brought into the maxillary sinus by the implant during its placement (32).

Based on this concept, the multi-cutting HS drill was designed to collect and retain bone fragments during socket preparation and the maxillary sinus cortical bone erosion. Subsequently, the bone is inserted with collagen into the space created inside the sinus cavity. An interesting finding frequently observed when no filler materials are used is direct contact between the implant apices and the sinus mucosa after approximately 3-4 months of healing.

Volpe et al. (33), in a retrospective study using a transcrestal technique with an osteotome without graft material but only with the use of collagen, immediately after the surgical procedure, the average membrane elevation was 3.8±1.1mm, while at follow-up after 5-13 years of loading, the average regeneration was 2.4±1.4. Still, the new position of the maxillary sinus cortical bone was clearly evident.

Similar results have been found in this group of patients. The initial millimeter of slight radiopacity above the apex of the implant, present immediately after surgery, is presumably due to collagen and blood interposed between the implant and the sinus mucosa. During healing, membrane movements prevent clot stabilization and, consequently, the formation of new bone above the implant apices.

M. Jungner et al. (34), in a follow-up study on cases of maxillary sinus floor augmentation with a lateral technique, CBCT detected that implant apices often protrude through the grafted area but are covered by a healthy sinus membrane. Even maxillary sinuses filled with autologous bone have a resorption during the first months of healing. Johansson et al. (35) found a resorption rate of bone grafts taken from the iliac crest of 47% in the first 6 months of healing and implant apices in contact with the sinus mucosa. However, no conclusive data in the literature reporting the possible advantage and maturation of a bone graft in the apical portion of the implant (36).

In the past, membrane perforation was the most frequent complication encountered with the transcrestal technique. Today, with the introduction of new, increasingly atraumatic burs and inserts, we have a decrease in the percentage of perforations of 3.8%. Sang-Hoon Ahn et al. (38) performed 391 maxillary sinus floor elevations with specific reamers for site preparation and simultaneous implant placement in 380 patients.

Eighteen (4.6%) perforations of the Schneider membrane occurred, and the 2-year survival rate was 95.4%. The success rate was 92.7% in sites with a sinus floor <4 mm and 96.4% in sites with bone height >4 mm. None of the patients experienced any discomfort during the procedure.

Trombelli L. et al. performed 30 transcrestal sinus lifts using the "Smart Lift" technique, which is based on a sequence of manual drills and elevators. They encountered only one perforation with the Valsalva maneuver immediately after fracturing the sinus cortical bone (39).

The difficulty with all crestal sinus lift techniques is controlling the integrity of the membrane throughout the entire lifting process. Perforation can occur at any stage of the procedure, from fracturing the floor of the maxillary sinus to detaching and lifting the membrane to graft insertion and finally during implant placement. Garbacea et al. (40)

macroscopically investigated sinus membrane perforation during surgery using three transcrestal sinus floor elevation techniques. Intact maxillary sinuses from twenty human cadavers were used for the study. Real-time sinus endoscopy images, periapical digital radiographs, and cone-beam computed tomography (CBCT) were used to evaluate the outcome of each surgical procedure.

No statistically significant differences were found in the perforation rate among the three surgical techniques. Endoscopy showed a higher frequency of perforations during implant placement compared to instrumentation or graft insertion in all three techniques. This pilot study demonstrated that sinus membrane perforation can occur at any time during the sinus lift procedure, regardless of the surgical technique used. The particular design of the multi-cutting drill (with Ø 2.8-3.2-4.2 with 18 cutting edges along the axis of the drill for 3 mm and 6 cutting edges at the tip) allows for controlled erosion of the cortical floor of the maxillary sinus, exposing the membrane without damaging it. Mucosal elevation is the most delicate moment of the procedure. Various techniques have been devised to detach the sinus mucosa from the sinus floor.

Kao DW et al. (41) used an uncontrolled water jet pressure from a plastic syringe that did not allow for equal distribution of hydraulic pressure on the membrane, and it was not uniformly lifted as fluids flowed from the crestal osteotomy. In this regard, screw elevators have been developed that are inserted through the alveolar crest into the maxillary sinus to seal the osteotomy and allow for direct fluid passage to the Schneiderian membrane (42).

Pommer et al. (43), in an in vitro study on 20 human cadaver sinuses, demonstrated that the Schneiderian membrane can be stretched up to 132.6% of its original unidimensional size and up to 124.7% bidimensionally.

The Authors argue that in the elevation of the sinus floor by the crestal approach, a correct circumferential detachment of the membrane before its elevation is crucial to reduce tensions and decrease the risk of perforations. With the sinus lift detachors included in the Rialto kit, it is possible to elevate the membrane to create a space that can accommodate a potential bone substitute or collagen alone. In our procedure, the initial detachment of the membrane is performed with the external and internal elevators at a 60° angle, with the interposition of small collagen leaflets between the membrane and the manual instruments, using a gentle movement similar to the lateral window procedure.

Subsequently, collagen is added with the "rounded sinus lift detachor" until the desired height is reached. The use of collagen prevents direct contact between the membrane and the instruments and, subsequently, contact with the apex of the implant. Furthermore, through these manual instruments, tension reduction is achieved at the margins where the membrane is still attached to the floor of the maxillary sinus. To avoid perforations during implant placement, we raise the sinus mucosa approximately 1 mm higher, using manual instruments equipped with stops, compared to the part of the implant that will be inserted into the sinus. This technique prevents further stress on the mucosa during implant placement, which we believe is the cause of perforations noted by Garbacea et al. (44) through endoscopy.

In our study, the integrity of the mucosa was evaluated with the Valsalva maneuver at each surgical step, both for the sequence of drills and manual instruments, and we did not find any lesions. To achieve these results, a careful pre-surgical study of the sinus anatomy is important: the absence of septa, oblique walls in the sinus lift area, and residual bone height ≥4 mm (45).

Reiser et al. (46) identified sinus anatomy as a possible etiology of perforations. These authors examined the membrane response to BAOSFE in human cadavers. Of the 25 sites treated with implant insertion, 6 showed perforations, with a rate of 24%. Between these 6, 4 perforations were associated with the proximity of the osteotomy to the antral septa or mesio-vestibular wall. The same principle is added to a high risk of transcrestal perforation in sites with oblique sinus floors. Another complication is benign paroxysmal positional vertigo (BPPV), which has been reported following the use of osteotomies. Symptoms include dizziness or vertigo, loss of balance, and nausea. Several authors have hypothesized that the factors responsible for BPPV following crestal surgery may be the percussive force exerted on the maxilla by osteotomies and head hypertension during surgery (47).

Di Girolamo M. et al. (48) hypothesized that percussion with a hammer on osteotomes causes percussive forces that detach heavy inorganic particles (otoliths) from the otoconial layer of the utricular macula. The use of HS multitoothed drills, with depth stops, eliminates the percussive forces generated by the hammer on the osteotomes, thus avoiding the annoying sensation that patients report during surgery and the related complication of BPPV. In our study, no patient complained of benign paroxysmal positional vertigo. In conclusion, the Rialto technique is based on the concept of bone regeneration and simultaneous osseointegration. The specially designed multitoothed bur exposes the sinus mucosa and retains bone to be reused as filling material without showing any adverse effects. The sequence of intrasinus scalers allows for the gentle detachment of the mucosa from the sinus floor, reducing tension during its lifting, as occurs with the lateral window technique (49, 50).

CONCLUSIONS

The results of our study confirm that bone formation within the maxillary sinus occurs when using a collagen sponge in combination with the transcrestal "Rialto" technique. This technique is minimally invasive and reduces the most common complications, such as perforation of the sinus mucosa, benign paroxysmal positional vertigo (BPPV), and discomfort for the patient, and can be combined with any type of implant used.

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Retrospective Observational Study

USE OF TI-MESH FOR GUIDED BONE REGENERATION IN VERTICAL AUGMENTATIONS WITH AUTOLOGOUS BONE. A RETROSPECTIVE OBSERVATIONAL STUDY OF LONG-TERM REMODELING WITH 5-YEAR FOLLOW-UP

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ABSTRACT

Numerous materials and techniques are used for guided bone regeneration in edentulous patients. Autologous bone with Ti-mesh titanium grids offers excellent osteoconductive, osteoinductive, and osteogenic properties, reducing post-operative healing times and costs compared to heterologous materials. This retrospective observational study aims to evaluate, at a 5-year follow-up, the remodeling of atrophic ridges regenerated vertically using Ti-mesh and autologous bone. Following vertical bone regeneration with autologous material and Ti-mesh, 35 implants were placed in 18 healthy, non-smoking patients (7 women and 11 men) with an average age of 53 years, who presented a Cawood and Howell grade V or VI mandibular/maxillary atrophy. Six maxillary and 12 mandibular segments were rehabilitated. All patients entered a professional oral hygiene control program scheduled every 6 months for the duration of the entire follow-up. The study involved measuring the bone increase in the vertical direction via intraoral radiographs performed with the long cone technique or using CBCT data. Each patient underwent level I or II radiographic investigations at T0 (surgical rehabilitation), T1 (prosthetic rehabilitation) and T2 (5 years after rehabilitation). The bone defects on the mesial and distal sides of the implants were measured in mm at T0, T1 and T2. The GBR Ti-Mesh technique in association with autologous bone in particulate form allowed a gain in bone height on average equal to 5.6 ± 0.65 mm at the time of removal of the titanium mesh and an average resorption after 5 years of 1.06 ± 0.45 mm. This corresponds to an average resorption after 5 years of 19% of the autogenous bone grafted at T0. Osseointegration was achieved in all 35 implants at the time of abutment connection. After a minimum of 5 years of functional loading, all 35 implants included in this study caused no pain, sensitivity or mobility and maintained stable osseointegration. Therefore, the cumulative survival and success rates of the implants at the end of the follow-up period were 100% and 88.6% respectively as 4 out of 35 implants (11.4%) presented a greater bone resorption. The GBR Ti-Mesh technique allowed the regeneration of large vertical bone defects in patients with severe bone atrophy. It guaranteed predictability and reproducibility of results for all 35 implant sites. The use of autologous bone yielded results comparable to implants in defects regenerated with heterologous bone. Autologous bone is presented as a material of choice for its osteoinductive, osteoconductive, and osteogenetic properties, as well as its low cost and predictability. The use of autologous bone in the vertical GBR technique with Ti-mesh resulted

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in vertical bone resorption comparable to implants in regenerated bone with heterologous biomaterial, reduced post-operative healing times, lower costs, and bone remodeling indistinguishable from native bone. Autologous bone has proven to be a valid alternative to heterologous bone. Further studies could expand the sample size and data available.

KEYWORDS: *guided bone regeneration, vertical augmentation, autologous bone, Ti-mesh, biomaterials*

INTRODUCTION

The correct diagnosis of the degree of bone atrophy is the basis of an adequate treatment plan aimed at restoring correct volumes and specific implant-prosthetic rehabilitations for each individual patient (1-3). Bone atrophy is connected to factors that have different origins, divided into two broad categories: factors of genetic and epigenetic origin and environmental factors. The former include genetic alterations that affect the development of the entire dento-alveolar complex in the different phases of growth. The latter include total or partial loss of dental elements due to trauma, fractures, periodontitis, endo-periodontal lesions, cystic lesions or radiotherapy of the head and neck area. The lack of traction and pressure forces exerted by the dental elements during chewing leads to a complete involution first of the alveolar process and then of the mandibular and maxillary basal bone. To quantitatively evaluate the loss of alveolar bone, the Cawood and Howell (4) classification, developed in 1988, is still used today, in which 6 resorption classes are divided. Through guided bone regeneration and prosthetically guided implantology, all regenerative/reconstructive procedures of hard and soft tissues are previously programmed in size and in positioning the implants in an ideal position, both from an aesthetic and functional point of view (5).

Guided bone regeneration currently allows the effective correction of horizontal, vertical and combined defects, even if they are generally limited in size (6). There are currently numerous techniques and various graft materials that allow a predictable long-term regeneration/reconstruction of the deficient alveolar process to be achieved, in order to optimize the insertion of implants in a prosthetically guided manner and greatly improve the final result (7). The techniques are divided into the following groups: guided bone regeneration, apposition or interposition bone grafts (8-10), elevation of the floor of the maxillary sinus (11), osteogenetic distraction (12), expansion of the alveolar ridges (13), transposition of the inferior alveolar nerve (14) and revascularized bone transplants (15). Focusing on the first technique, there are numerous bone filling materials used for regeneration. They can be obtained from the patient himself as autogenous bone grafts or autografts, from an individual of the same species (frozen, lyophilized or lyophilized and demineralized allogeneic bone), from animals such as bovine (16) or equine (17) (xenografts), from bone-like minerals derived from corals (18) or calcified algae without the organic component or can be synthetic products such as calcium phosphates, bioactive glass (19) or polymers. In this study we focus on the use of autologous bone graft, today considered the gold standard of regeneration as it possesses all the characteristics of a good biomaterial such as biocompatibility, osteoconductive, osteoinductive or osteogenetic properties. Its harvest, however, always requires a second intra-or extra-oral surgical site which exposes the patient to increased surgical risk and morbidity. The availability of autogenous bone is often limited and partial resorption of the graft is observed. The principle underlying this family of reconstructive techniques is that semi-permeable barriers placed above a defect, such as reabsorbable membranes of collagen (20) or pericardium of animal origin (21), reabsorbable membranes obtained by synthesis, for example those of polylactic-polyglycolic acid or non-absorbable membranes such as those in e-PTFE (22) or titanium grids, separate the surrounding soft tissues for a variable period of time from the area in which the regeneration of the missing bone tissue must take place, carrying out an excellent containment and stabilization action on the clot and the underlying bone particulate.

Among non-absorbable membranes, titanium grids customized with CAD-CAM techniques have recently been introduced on the market, obtained by synthesis starting from three-dimensional resin models obtained from DICOM files of a bone defect. These new titanium grids, known on the market as Ti-Mesh (23-30), are characterized by extreme precision and easy adaptability to the bone defect (23). This simplifies the regenerative procedure and significantly reduces operating times. Ti-meshes not only allow for a better blood supply but even if exposed, they often resist infection (24). The advantages of Ti-mesh material include that it creates a rigid structure to provide a safe space for new bone to form and that it creates a better tent effect than resorbable membranes (25). It has a porous structure to allow for better blood supply and prevents bone resorption during healing. However, shaping the Ti-mesh material to fit the bone defect and fixing it precisely and stably is not always easy (26). Furthermore, the need to surgically intervene a second time to remove the grid represents a limit to the routine use of this device (27). The use of Ti-mesh is most commonly combined with various types of bone grafts (28). According to one study, coupled with autogenous block grafting, Ti-mesh achieved an average vertical gain of 4.8mm (25). A combination of inorganic bovine bone mineral and autogenous bone graft resulted in an average increase of 2.86 mm in vertical ridge height (31). In another study where inorganic bovine bone

mineral and autogenous bone were mixed in a ratio of 30:70, the mean vertical gain was 3.71 mm (16). Bovine bone was also used as the sole graft material supported by a configured Ti-mesh, resulting in mean vertical bone gain (VBG) of 5.2 mm after 9 months (32). Allograft use, however, has been reported less frequently combined with Ti-Mesh.

The aim of this observational retrospective study is to evaluate, through the use of intraoral radiographs and/or cone-beam CT, the long-term bone remodeling of atrophic ridges regenerated vertically using Ti-mesh and autologous bone alone.

MATERIALS AND METHODS

Patient selection

Between 2015 and 2018, 18 partially edentulous patients (7 women and 11 men) with an average age of 53 years (range, 35 to 71 years) were selected for our study (Table I). The patients came at our attention for implant-prosthetic rehabilitation. The study included individuals over 18 years of age who presented grade V or VI segments of mandibular/maxillary atrophy according to the Cadwood and Howell classification with an insufficient amount of residual bone to position single or multiple implants in the correct prosthetic position in the anterior or posterior area. A total of 6 maxillary segments and 12 mandibular segments were rehabilitated. Those who agreed to enter a 5-year postoperative follow-up program were also included. Each patient signed the consent form for the operation after being correctly informed about the execution and the possible risks and complications. However, individuals with the following adverse conditions were excluded: local infections, smokers of more than 10 cigarettes a day, carriers of systemic diseases such as uncompensated diabetes (glycated hemoglobin levels >7 mg/%), patients with osteoporosis, being treated with drugs that interfere with bone metabolism, undergoing anti-tumor chemotherapy treatment, with a history of head and neck radiotherapy, with liver, blood or kidney disease, immunosuppressive conditions, current use of corticosteroids, current pregnancy, inflammatory or -immune.

Patients who were poorly motivated for correct oral hygiene were also excluded. Following a careful anamnestic investigation and a clinical examination for treatment planning, each patient received a prophylaxis session with ultrasonic scalers (P5 Booster, Acteon, De Gotzen S.r.l., Olgiate Olona,Varese, Italy) and instructions for correct oral hygiene at home. If necessary, scaling and root planing sessions were carried out. Before starting the surgical procedure, all patients demonstrated adequate plaque control (full-mouth plaque index <25%). First and second level radiographic investigations were carried out for each patient, including periapical radiographs, orthopantomographies, and computed tomography (CT).

Table I. *Collection of amnestic data from treated patients.*

Patient	Genre	Age in years	Implants	Surgery site	Complications
1	F	54	2	Jaw	None
2	M	37	2	Jaw	None
3	M	62	2	Maxilla	None
4	F	45	2	Jaw	Post pain
5	M	39	2	Jaw	None
6	F	43	2	Jaw	None
7	F	52	2	Jaw	None
8	M	65	2	Jaw	Swelling
9	M	71	2	Jaw	Post pain
10	F	48	2	Jaw	None
11	M	55	2	Jaw	None
12	M	57	3	Maxilla	None
13	M	64	3	Maxilla	None
14	F	68	3	Maxilla	None
15	M	41	1	Maxilla	None
16	F	59	1	Maxilla	None
17	M	66	1	Jaw	None
18	M	35	2	Jaw	None

Surgical procedures

All patients were pre-medicated with 3 g of amoxicillin 1h before surgery. In the case of penicillin allergy, 600 mg of clindamycin was prescribed 1h before. All procedures were performed by an experienced clinician. Before surgery, patients were asked to rinse with 0.20% chlorhexidine for 2 minutes. After local anesthesia, a crestal incision and an intrasulcular buccal incision were made on the adjacent teeth, including divergent buccal incisions using a #15c surgical

blade. Full thickness mucoperiosteal flaps were raised to expose the structure and the underlying bony defect. The remaining fibrous tissue was removed from the recipient site and corticalization of the medullary space was performed using small round surgical drills to improve the vascularization of the recipient bed. In all cases, bone particulate was collected from the mandibular ramus using a bone bur. At the same time, the dental implants were positioned according to the standard protocol of the implant system for a total of 35 implants in 18 patients. After preparation of the implant osteotomy sites, the implants were screwed into place at low speed (10 rpm) using a contra-angle handpiece. All implants showed good primary stability after insertion with a torque of 35 Ncm.

For each segment to be rehabilitated, a Ti-mesh was cut and fixed in place with three or more titanium micro-screws in the buccal and lingual/palatal portion of the native bone to maintain and protect the graft. Subsequently, it was covered by making periosteal release incisions to extend the flap as coronally as possible to the metal mesh. Horizontal mattress sutures were used to achieve tension-free soft tissue closure.

The postoperative regimen included amoxicillin plus clavulanic acid, 1 g every 12 hours for 6 days, ibuprofen 600 mg every 8 hours for 7 days, and 0.2% chlorhexidine mouthwash rinses every 12 hours for 1 week. Patients were asked to avoid brushing the surgical site and to avoid smoking for a few days after surgery. The sutures were removed after 15 days. The patients were called for a check-up after 1 month and for the oral hygiene session 3 months after implant insertion.

In all cases, between 3 and 5 months after implant insertion, the Ti-mesh was removed with a second surgical operation and the implants were rehabilitated. Nineteen fixed partial prostheses were inserted. The definitive screw-retained prostheses were made of titanium and ceramic or composite resin. All patients were provided with careful oral hygiene instructions at the time of denture placement and were enrolled in a maintenance care program every 6 months during the 5-year monitoring period.

Radiographic analysis of bone augmentation

All patients underwent intraoral radiographs and cone-beam CT at baseline (T0), removal of the titanium Ti-mesh and prosthesis after 4 months (T1) and after a 5 years of follow-up (T2). To verify the vertical bone augmentation and, therefore, the size of the residual bone defect at restoration and follow-up, measurements were performed on periapical radiographs using the DbSwin dental imaging software from Dürr Dental (Muggiò, MB, Italy). For each implant, the vertical bone defect on both the mesial and distal sides was calculated at T0, T1, and T2 in terms of mm, starting from the most coronal point of the bone defect up to the most coronal point of the implant neck. Below are the radiological (Fig.1a-d) and clinical (Fig.2a-c) images of a case.

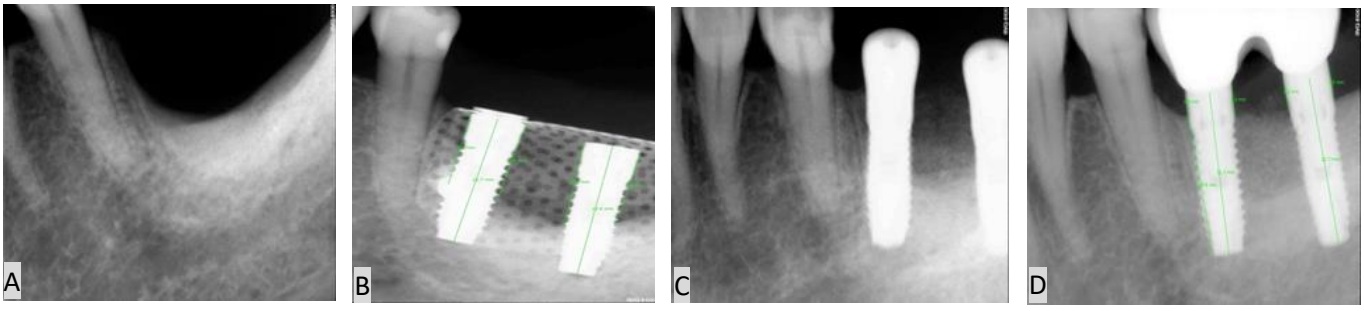

Fig. 1. A): *Initial bone defect;* ***B****): X-ray post vertical bone augmentation with autologous material, implant insertion and positioning of the Ti-Mesh secured with pins (****T0****);* ***C****): X-ray 4 months after removal of the Ti-Mesh and insertion of abutment onto the implants (****T1****);* ***D****): X-ray at a minimum follow-up of 5 years after prosthesis and implant loading (****T2****).*

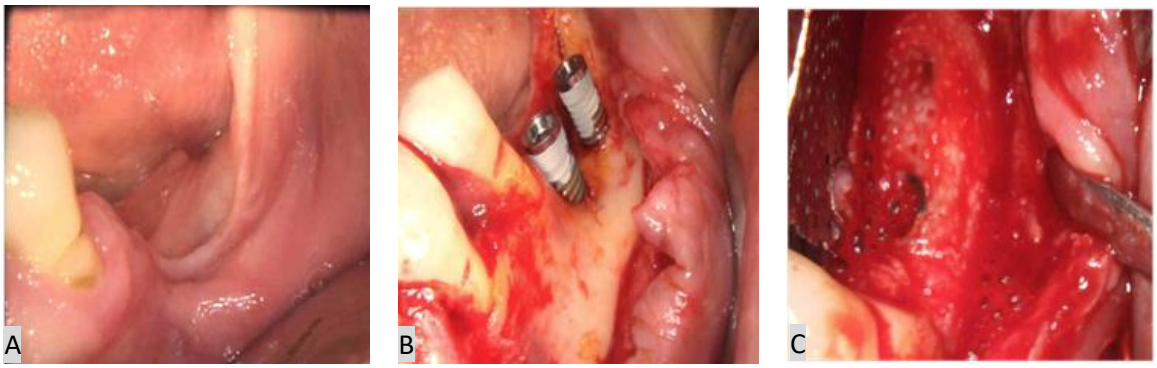

Fig. 2. ***A)****: Initial bone defect;* ***B)****: Vertical bone augmentation with autologous material, implant insertion, and positioning of the pin-locked Ti-Mesh (****T0****);* ***C)****: Four months after removal of the Ti-Mesh and abutment of the implants (****T1****).*

Peri-implant clinical parameters

For a period of 5 years, all patients were recalled for professional hygiene sessions and evaluated according to a standard protocol every 6 months from the moment of implant insertion. The health and stability of the soft tissues around the implants were assessed using the modified plaque index (MPI) (33) and modified bleeding index (MBI) (34) recorded at the mesial, distal, buccal, and lingual/palatal aspects of each implant. At the same time, the peri-implant probing depth (PD) was recorded at the nearest millimeter using a calibrated mechanical probe with a constant probing force. An MPI, MBI, and PD value was calculated for each implant based on the average of the four values obtained. All clinical measurements were performed by a single investigator.

Implant survival and success rates

The success criteria for this study were chosen based on Alberktsson et al. (1) and included the following: the absence of persistent subjective complaints, such as pain, foreign body sensation, and/or dysesthesia; absence of peri-implant infection with suppuration; lack of mobility; absence of continuous radiolucency around the implant and mean bone resorption (MBR) <1.5 mm in the first year of operation and <0.2 mm per year in subsequent years. Implants that had all of the above criteria, but showed MBR above established parameters, were considered survivors.

Statistical analysis

The measurements were collected at T0, T1 (i.e., at the restoration of the implants), and T2 (i.e., at a minimum follow-up of 5 years). The values were obtained using the DbSwin dental imaging software from Dürr Dental and were entered into the tables in the results. Subsequently, it was possible to calculate the average value of resorption and, therefore, the remaining bone defect on the mesial and distal sides of each implant.

RESULTS

All 18 patients completed the study and demonstrated satisfactory function of the implant-supported prosthesis at the minimum 5-year examination. The clinical results of the study are summarized in Table II.

At all but 3 augmented sites, postoperative healing was uneventful and complication-free. In 2 out of 18 patients (11%) medium-level post-operative pain occurred and was kept under control by a higher dose of ibuprofen compared to other patients who did not need to take painkillers. One patient out of 18 (5%) showed post-operative swelling that resolved spontaneously in 3-4 days.

Radiographic results of bone augmentation and resorption

Upon removal of the titanium mesh, which took place in a time varying from 3 to 5 months (T1), the use of autologous bone in the form of particulate with the GBR Ti-Mesh technique led to an average percentage of bone resorption equal to zero. The GBR Ti-Mesh technique in association with autologous bone in particulate form, allowed an average bone height gain of 5.6 ± 0.65 mm upon removal of the titanium mesh and an average resorption after 5 years of 1.06 ± 0.45 mm. This corresponds to an average resorption after 5 years of 19% of the autogenous bone grafted at T0. The results of the individual measurements are presented in the tables below (Table II-IV).

Table II. *Measurements of the distance from the apex of the fixture to the most coronal point of the regeneration, of the mesial bone defect M, and of the distal bone defect D to the implant in mm upon insertion (T0).*

T0 - FIXTURE POSITIONING										
PATIENT INFORMATION		FIXTURE N°1			FIXTURE N°2			FIXTURE N°3		
	TYPE OF RX	T0 MEASURE OF GBR	T0 MEASURE OF THE MESIAL DEFECT	MEASURE OF THE DISTAL DEFECT	T0 MEASURE OF GBR	T0 MEASURE OF THE MESIAL DEFECT	MEASURE OF THE DISTAL DEFECT	T0 MEASURE OF GBR	T0 MEASURE OF THE MESIAL DEFECT	MEASURE OF THE DISTAL DEFECT
PATIENT 1	PERIAPICAL X-RAY	12.7	7.2	7.8	13	8.2	7.2	*	*	*
PATIENT 2	PERIAPICAL X-RAY	10.4	1.6	3.9	10.5	4.7	6.2	*	*	*
PATIENT 3	PERIAPICAL X-RAY	14.5	5.1	6.1	14.8	5.7	4.2	*	*	*
PATIENT 4	PERIAPICAL X-RAY	6	3.5	3.3	6.3	3.5	3.2	*	*	*
PATIENT 5	PERIAPICAL X-RAY	13	2.1	7.7	15	10.4	8.7	*	*	*
PATIENT 6	PERIAPICAL X-RAY	11	3.5	6.1	12	6.4	0	*	*	*
PATIENT 7	PERIAPICAL X-RAY	14.6	4.2	6.6	14	5.5	-1.2	*	*	*
PATIENT 8	PERIAPICAL X-RAY	8.1	2.9	1.9	9.3	2.1	0.7	*	*	*
PATIENT 9	PERIAPICAL X-RAY	8.4	3.5	4.2	9.6	5.3	3.7	*	*	*
PATIENT 10	PERIAPICAL X-RAY	10	3.2	3.7	10.1	3.2	3.2	*	*	*
PATIENT 12	PERIAPICAL X-RAY	8.6	4.2	5.1	*	*	*	*	*	*
PATIENT 13	PERIAPICAL X-RAY	10	0	2.3	12	4	4.3	12.5	4.5	2.2
PATIENT 15	PERIAPICAL X-RAY	15	8.8	9.4	14.2	5.7	5.7	9.9	1.8	2.2
PATIENT 16	PERIAPICAL X-RAY	7.5	4	3.7	10.5	6	6.8	13.9	8	3.4
PATIENT 17	PERIAPICAL X-RAY	15.4	7.4	7.5	*	*	*	*	*	*
PATIENT 18	PERIAPICAL X-RAY	13.2	3.8	2.7	*	*	*	*	*	*
PATIENT 20	PERIAPICAL X-RAY	12.3	8.8	8.9	*	*	*	*	*	*
PATIENT 23	PERIAPICAL X-RAY	14	3.2	8.7	15	9.9	7.7	*	*	*

Table III. *Measurements of the distance from the apex of the fixture to the most coronal point of the regeneration of the mesial bone defect M and the distal bone defect D in mm at implant restoration 4 months after grafting (T1).*

T1 - implant prosthesis										
PATIENT INFORMATION		FIXTURE N°1			FIXTURE N°2			FIXTURE N°3		
	TYPE OF RX	T0 MEASURE OF GBR	T0 MEASURE OF THE MESIAL DEFECT	MEASURE OF THE DISTAL DEFECT	T0 MEASURE OF GBR	T0 MEASURE OF THE MESIAL DEFECT	MEASURE OF THE DISTAL DEFECT	T0 MEASURE OF GBR	T0 MEASURE OF THE MESIAL DEFECT	MEASURE OF THE DISTAL DEFECT
PATIENT 1	PERIAPICAL X-RAY	11.5	0	0	11.5	0	0	*	*	*
PATIENT 2	PERIAPICAL X-RAY	10	1.3	0	9.9	0	0	*	*	*
PATIENT 3	PERIAPICAL X-RAY	14.5	0	0	14.8	0	0	*	*	*
PATIENT 4	PERIAPICAL X-RAY	6.1	1.5	0.6	6.2	0.6	1	*	*	*
PATIENT 5	PERIAPICAL X-RAY	13	0	0	15	0	0	*	*	*
PATIENT 6	PERIAPICAL X-RAY	10.1	-0.7	-0.5	12	0	-1.4	*	*	*
PATIENT 7	PERIAPICAL X-RAY	14.9	0	0	14.8	0	-1.4	*	*	*
PATIENT 8	PERIAPICAL X-RAY	8.1	-1.6	-1.7	9.3	-0.6	-0.7	*	*	*
PATIENT 9	PERIAPICAL X-RAY	8.4	0	0	9.6	0	0	*	*	*
PATIENT 10	PERIAPICAL X-RAY	9.8	0	0	9.4	-1.4	-0.9	*	*	*
PATIENT 12	PERIAPICAL X-RAY	7.9	0.9	2	*	*	*	*	*	*
PATIENT 13	PERIAPICAL X-RAY	10	-0.7	-1.5	12	1.2	0	12.5	0	0
PATIENT 15	PERIAPICAL X-RAY	14.8	1.2	2.1	14.3	1.9	1.4	10.1	0.9	1.5
PATIENT 16	PERIAPICAL X-RAY	7.9	0	0	10.5	0	0	13.9	0	0
PATIENT 17	PERIAPICAL X-RAY	15.1	0	-0.7	*	*	*	*	*	*
PATIENT 18	PERIAPICAL X-RAY	13.2	0	0	*	*	*	*	*	*
PATIENT 20	PERIAPICAL X-RAY	12	0	-0.6	*	*	*	*	*	*
PATIENT 23	PERIAPICAL X-RAY	14.8	0	0	15	0	0	*	*	*

Table IV. *Measurements of the distance from the apex of the fixture to the most coronal point of the regeneration of the mesial bone defect M and the distal bone defect D in mm at a 5-year follow-up (T2).*

T2 - follow-up at 5 years										
PATIENT INFORMATION		FIXTURE N°1			FIXTURE N°2			FIXTURE N°3		
	TYPE OF RX	T0 MEASURE OF GBR	T0 MEASURE OF THE MESIAL DEFECT	MEASURE OF THE DISTAL DEFECT	T0 MEASURE OF GBR	T0 MEASURE OF THE MESIAL DEFECT	MEASURE OF THE DISTAL DEFECT	T0 MEASURE OF GBR	T0 MEASURE OF THE MESIAL DEFECT	MEASURE OF THE DISTAL DEFECT
PATIENT 1	PERIAPICAL X-RAY	12.30	1.80	2.30	12.70	2.50	2.50	*	*	*
PATIENT 2	PERIAPICAL X-RAY	10.10	1.20	1.40	10.20	1.00	1.80	*	*	*
PATIENT 3	PERIAPICAL X-RAY	12.80	0.60	0.10	13.80	1.50	0.00	*	*	*
PATIENT 4	PERIAPICAL X-RAY	6.20	2.10	0.90	6.20	1.20	1.20	*	*	*
PATIENT 5	PERIAPICAL X-RAY	12.80	0.00	0.00	14.70	-0.80	-1.60	*	*	*
PATIENT 6	PERIAPICAL X-RAY	10.40	0.00	1.00	12.40	0.90	0.70	*	*	*
PATIENT 7	PERIAPICAL X-RAY	14.40	4.00	2.30	14.20	2.40	3.20	*	*	*

PATIENT 8	PERIAPICAL X-RAY	7.90	-0.80	-0.50	9.80	0.00	1.00	*	*	*
PATIENT 9	PERIAPICAL X-RAY	8.40	1.10	0.90	9.80	1.60	0.60	*	*	*
PATIENT 10	PERIAPICAL X-RAY	10.10	1.40	1.90	9.90	1.00	0.80	*	*	*
PATIENT 12	PERIAPICAL X-RAY	8.40	1.10	2.20	*	*	*	*	*	*
PATIENT 13	PERIAPICAL X-RAY	10.10	1.60	1.30	13.00	2.10	1.50	12.90	1.00	0.60
PATIENT 15	PERIAPICAL X-RAY	15.10	1.30	2.40	14.60	2.00	2.40	10.40	1.70	2.10
PATIENT 16	PERIAPICAL X-RAY	10.10	0.00	-0.90	12.70	1.70	1.50	12.30	1.40	0.20
PATIENT 17	PERIAPICAL X-RAY	15.40	1.70	1.50	*	*	*	*	*	*
PATIENT 18	PERIAPICAL X-RAY	13.30	1.40	0.90	*	*	*	*	*	*
PATIENT 20	PERIAPICAL X-RAY	11.80	0.00	-0.80	*	*	*	*	*	*
PATIENT 23	PERIAPICAL X-RAY	14.80	0.00	0.00	15.00	0.00	0.00	*	*	*

Results of peri-implant clinical parameters

The mean MPI values at 6 months, 1 year, and up to 5 years after the start of prosthetic loading were 0.25±0.39, 0.31±0.35, and 0.36±0.27, respectively. The mean MBI values were 0.48±0.46, 0.52±0.41, and 0.6±0.45, respectively. No statistically significant increase in MPI or MBI was observed between baseline and subsequent years for implant sites.

The mean PD values at 6 months, 1 year, and at least 5 years after the start of prosthetic loading were 2.55±0.34 mm, 2.91±0.68 mm, and 3.02±0.61 mm, respectively. At the 5-year examination, 67% of all implants had PD <3 mm, and only 8.3% had PD >5 mm.

Implant survival results and success rate

Osseointegration was achieved in all 35 implants at the time of abutment connection. After a minimum of 5 years of functional loading, all 35 implants included in this study caused no pain, sensitivity, or mobility and maintained stable osseointegration. However, 4 of the 35 implants (11.4%) had MBR values higher than those proposed by Albrektsson et al. (1) as an index of the success of the implant. Therefore, the cumulative implant survival and success rates at the end of the follow-up period were 100% and 88.6%, respectively.

DISCUSSION

From the study carried out, it emerged that the use of autologous bone in the form of particulates in association with the GBR Ti-Mesh technique guarantees excellent results. Autologous bone in particulate form is, therefore, a material that allows regeneration of large bone defects to be achieved with predictable, reproducible, stable results over time and with almost no incidence of complications. This is clearly due to the better osteogenetic, osteoinductive, osteoconductive, and low resorption properties of autologous bone compared to heterologous material. In terms of implant survival, the use of autologous bone has determined results that are completely comparable to those of implants positioned in regenerated bone with heterologous bone (2).

The most important question that arises after alveolar ridge augmentation with the titanium mesh technique is whether the augmented bone can support functional loading through restored prosthetic implants and whether bone resorption occurs. This study demonstrated the possibility of achieving osseointegration with good conditions of the peri-implant tissues and satisfactory MBR values for implants positioned in atrophic ridges previously augmented with exclusively autogenous bone and Ti-mesh networks after 5 years of loading.

Pre- and post-augmentation CT measurements demonstrated significant bone regeneration. These results are comparable to those reported in other studies. Matsui et al. (35) evaluated the combined use of autografts and titanium mesh in a series of 15 patients with cleft lip and palate and reported a mean height increase of 4.4 mm.

A CT scan performed before and after the bone grafting procedure, as performed in this study, provided accurate and reliable measurements of bone gain. However, the high cost and risk of radiation exposure with this method limit its routine application. For this reason, we used low-dose cone beam CT in this study.

Follow-up examinations were performed every 6 months on each of the 35 implants placed in the augmented bone, and several clinical and radiographic parameters were evaluated at 5 years. All implants showed satisfactory osseointegration, and no patient suffered from inflammation, pain, or discomfort except 3 patients (16.6%) who presented swelling or pain immediately after the implant insertion procedure (Table I). The conditions of the peri-implant soft tissues

were evaluated. All abutments were surrounded by healthy and stable peri-implant soft tissues, probably due to rigorous periodontal monitoring and effort to maintain good oral hygiene. These data were confirmed by the values shown for the periodontal parameters used to evaluate the condition of the peri-implant tissues (i.e., MPI, MBI, and PD). The literature indicates that successful implants generally allow probe penetration <3 mm (36).

Furthermore, pockets >5 mm deep should be viewed as a sign of peri-implantitis and may be related to progressive crestal bone resorption and implant failure (37-39). In the present study, only 4 of 35 implants (11.6%) had PD >5 mm and 2.5 mm MBR after 5 years of loading. Since plaque control compliance was adequate and the load on the implant-supported prosthesis was carefully assessed during follow-up visits, eliminating any possible occlusal interference, we hypothesized that the cause of bone resorption could be attributed to parafunctional habits. These habits can generate tensile or compressive forces on the bone-implant surface, resulting in rapid crestal bone loss in the absence of mucosal inflammation.

Caution should be used when interpreting data relating to peri-implant clinical parameters and when correlating these results with marginal changes in bone level. Furthermore, follow-up studies are needed to clarify the long-term influence of these factors on implant success.

CONCLUSIONS

From our study, it emerged that the 100% autogenous bone graft in the form of particulates, in association with the GBR Ti-Mesh technique, allows for the regeneration of large bone defects and over a long period of time (minimum 5 years), the volume of the autologous bone grafted in the form of particulate remains stable, except for minimal and completely physiological resorption (1.06+-0.45 mm). The use of only autologous bone together with Ti-Mesh resulted in vertical bone resorption comparable to that of implants positioned in regenerated bone with heterologous biomaterial, a reduction in post-operative healing times, a reduction in costs compared to heterologous biomaterials and a bone remodeling that made it indistinguishable from native bone. Further studies with the same parameters could be useful to expand the number of cases and consequently expand the number of data available.

Following this retrospective observational study, however, it is already possible to outline how autologous bone is a material that has excellent regenerative properties, and that over a long period of time it undergoes minimal physiological volume reabsorption, allowing stable results to be obtained over time and predictable.

Conflicts of interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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Authors' contributions

Gianluca Porcaro made substantial contributions to the conception and design of the manuscript as well as the acquisition, analysis, and interpretation of the data. All the authors participated in the drafting of the manuscript, and Fabrizio Carini reviewed it critically. All authors have read and approved the final version of the manuscript. All authors contributed equally to the manuscript and read and approved the final version of the manuscript.

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Case Series

QUAD ZYGOMATIC IMPLANTS: CASE SERIES

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ABSTRACT

Zygomatic implants (ZI) represent a groundbreaking advancement in the field of dental implantology. These specialized implants offer a viable solution for individuals with severe maxillary atrophy, where conventional implants may not be feasible. ZI are typically longer than conventional dental implants, ranging from 30 to 55 mm. They are anchored in the zygomatic bone, a dense and sturdy structure in the upper jaw. We reported a case series and discussed the literature.

KEYWORDS: *dental implants, maxillary atrophy, surgical technique, survival rate, zygomatic implants*

INTRODUCTION

Zygomatic implants (ZI) are indicated for patients with severe maxillary atrophy, eliminating the need for bone grafting (1-5). Understanding the intricate anatomy of the maxillary region is crucial for successful ZI placement. Variations in bone density, sinus morphology, and facial anatomy influence the feasibility and success of ZI procedures. The zygomatic bone plays a pivotal role in zygomatic implantology. Its robust structure provides a stable foundation for implant placement.

Variations in zygomatic bone anatomy must be considered during the planning and execution of ZI surgeries. ZI are longer than conventional dental implants, typically ranging from 30 to 60 mm. The surgical procedure involves precise placement in the zygomatic bone, avoiding critical structures such as the maxillary sinus and neurovascular bundles. Surgical techniques, including the sinus lift and intraoral approaches, demand a comprehensive understanding of maxillary anatomy.

Anatomical variations in the maxilla, such as pneumatization of the maxillary sinus and the presence of bony septa, can complicate ZI placement. Preoperative imaging is essential for assessing individual anatomical variations and tailoring the surgical approach accordingly.

Recent systematic reviews have defined the advantages of ZI. Wang et al. (2) assessed the predictability of ZI in regard to implant survival, technical and biological complications, and quality of life. ZI survival rate was 96.7%. Only a limited number of surgical complications were reported, with orbital perforation the most significant. Similar results were obtained for prosthetic complications (few occurrences). Additionally, patient satisfaction levels were high, approaching that of the general population. The authors concluded that maxillary rehabilitation by four ZI with no anterior support is a reliable approach.

Aboul-Hosn Centenero et al. (3) reviewed and compared the survival rates (SRs) of oral rehabilitations performed with 2 ZI combined with regular implants (RIs) versus 4 ZI. ZIs SR was 98.0%. For the control group (2 ZIs + 2 RIs) and the test group (4 ZIs), the implant SR was 98.6% and 97.4%, respectively. No statistically significant

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differences in terms of SRs were obtained between both groups. The results showed no statistical differences in using one or another treatment in terms of survival and failure rates. Reducing treatment time and morbidity related to regenerative approaches may be its main advantage. In conclusion, the zygoma quad seems to be the treatment of choice for the rehabilitation of the severely atrophic maxilla.

Gracher et al. (4) presented the treatment outcomes with ZI in rehabilitating the atrophic upper jaw. The survival rate of ZI was 98.22%. Different surgical techniques were used to place ZIs; however, the intrasinusal technique was the most used, and post-surgical sinusitis was the most common complication reported in the studies.

Solà Pérez et al. (5) performed a systematic review on ZI. The cumulative success rate of ZI for the treatment of severe maxillary atrophy was 98.5% at less than one year, 97.5% between 1 and 3 years, 96.8% between 3 and 5 years, and 96.1% after more than 5 years. The most commonly reported complications were soft tissue dehiscence, rhinosinusitis, and prosthetic failures. The treatment of severe lack of bone in the upper maxilla with ZI is a safe procedure, reaching a cumulative success rate of 96.1% after more than 5 years.

ZI offers several advantages, including reduced treatment time, avoidance of bone grafting procedures, and immediate loading capabilities. Immediate loading of ZI is a viable option in select cases. The biomechanics of ZI are influenced by their unique placement in the zygomatic bone, contributing to enhanced stability and long-term success. While ZI exhibits high success rates, clinicians must be vigilant regarding potential complications. Complications may include sinus-related issues, nerve damage, and implant failure. Long-term success studies provide insights into the durability and stability of zygomatic implant-supported prostheses (2-5). These studies track patient outcomes, implant survival rates, and potential complications over extended periods, contributing to the evidence base supporting the efficacy of ZI.

Regarding surgical procedures, one of the common techniques for zygomatic implant placement is the classical sinus lift approach. This involves accessing the zygomatic bone through a lateral window created in the maxillary sinus. Careful elevation of the sinus membrane allows for the insertion of the zygomatic implant. The intraoral approach is an alternative method involving access through the alveolar crest. This approach minimizes the need for external incisions and provides a more direct path to the zygomatic bone.

Advances in minimally invasive techniques have further refined the intraoral approach. In some instances, extra-maxillary techniques may be employed, allowing for zygomatic implant placement without entering the maxillary sinus. These techniques, such as the zygomatic tubercle approach, offer alternative paths to the zygomatic bone, reducing the risk of sinus-related complications. Here, we report a case series and review the literature.

CASE REPORT

Case 1

G.C., a 74-year-old nonsmoker female, came to our Clinic complaining about her smile. She had a far-advanced periodontal disease (Fig. 1-10). After careful examination, a full arch rehabilitation using zygomatic implants was performed. The prosthesis was delivered immediately after the intervention, and the patient was uneventful after 18 months.

After locoregional anesthesia and extraoral zygoma anesthesia, a full-thickness flap is elevated with vertical release incisions in the nasal spine and distal to the zygomatic pillar.

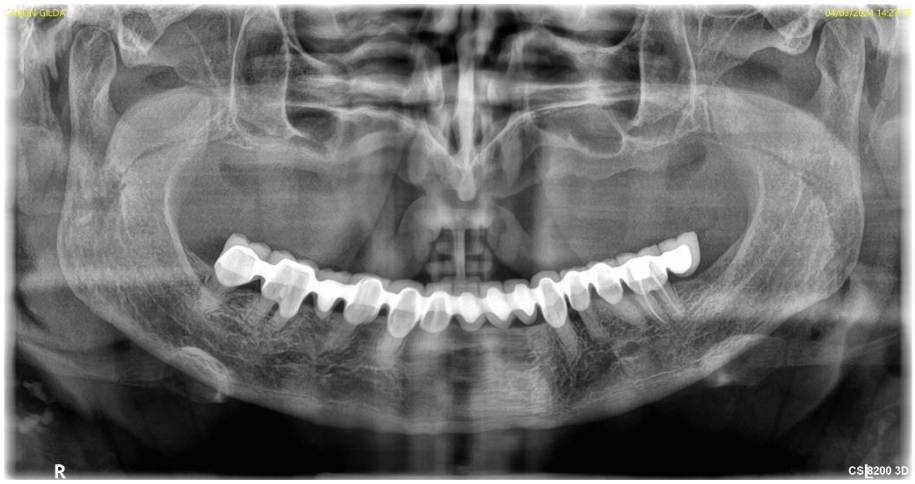

Fig. 1. *Pre X-ray.*

The approach is one emi-maxilla at a time; skeletonization reaches the piriform opening, the infra-orbit nerve proceeds to the inferior orbital border and continues through the zygomatic plate until the zygomatic arch, where the superficial fibers of the masseter muscles are cut to increase the possibility of view in the orbit border and the distal part of the zygomatic surface.

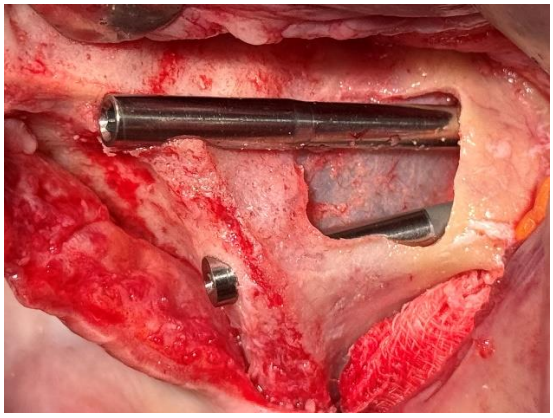

Fig. 2. *Sparing of the left sinus wall.*

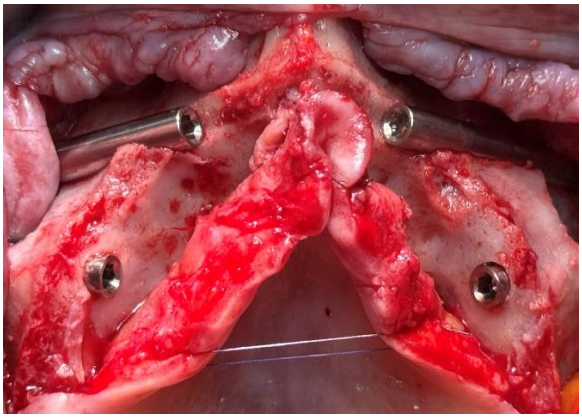

Fig. 3. *Positioning of zygomatic implant*

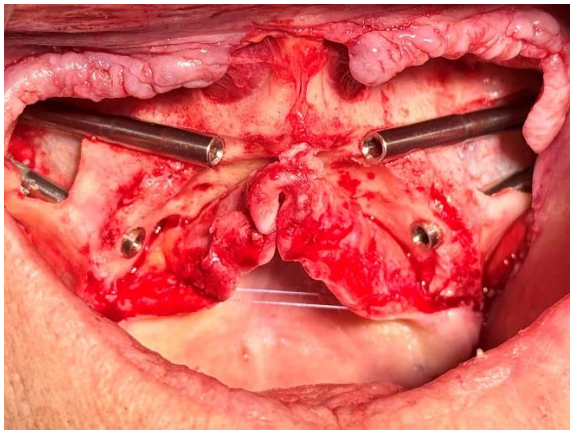

Fig. 4. *Fontal view*

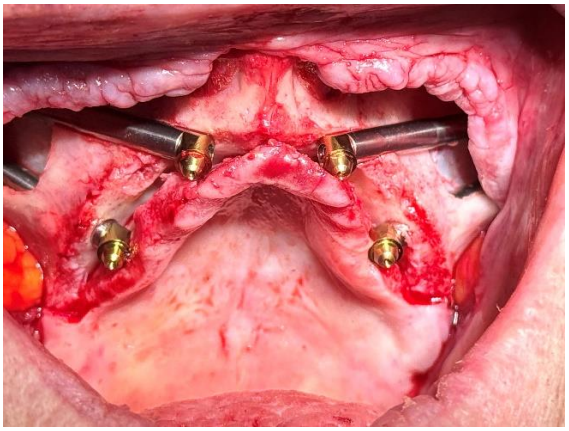

Fig. 5. *MUA tightening*

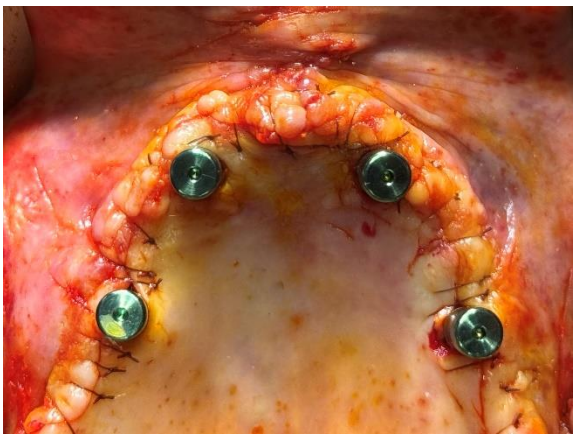

Fig. 6. *Soft tissue management*

The antrostomy is done in the upper part of the sinus close to the plateau of the zygomatic bone surrounding the sinus roof, and the Schneiderian membrane is carefully detached. Choosing the exit of our zygomatic implant in the alveolar ridge according to the ideal line, which is that the implant should not have invaded the orbit border or the infra-orbital nerve, is a key point. The slots are then prepared, creating a precise accommodation in the bone for the implant. The zygomatic bone is then approached with the burs, having care of working in and out so as not to overheat the bone and not to change the axis because the implant does not have to bend when placed.

Finally, implants are tightened, reaching torques close to 80Ncm easily. The other hemimaxilla is mirrored.

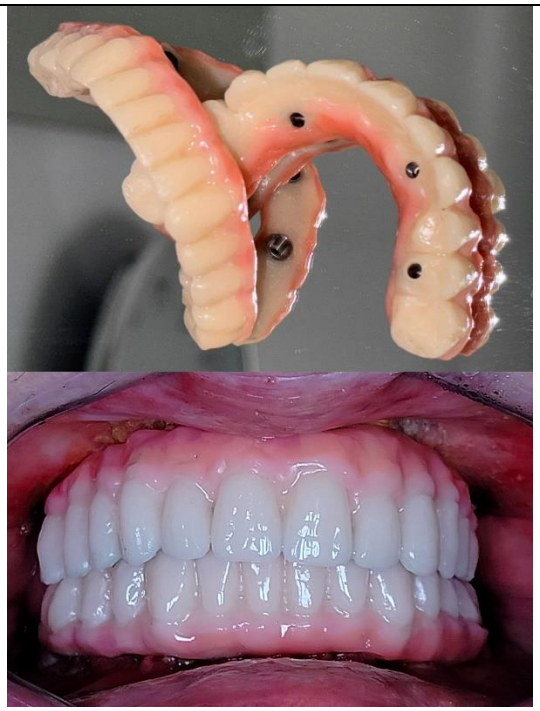

Fig. 7. *Prosthesis.*

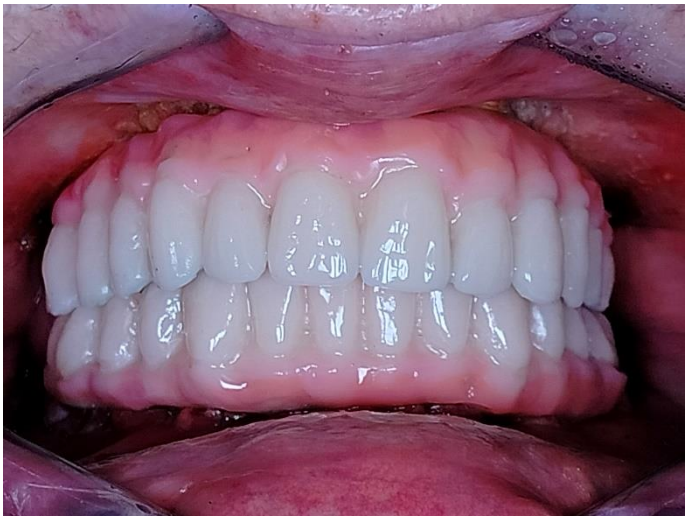

Fig. 8. *Delivery of the full arches.*

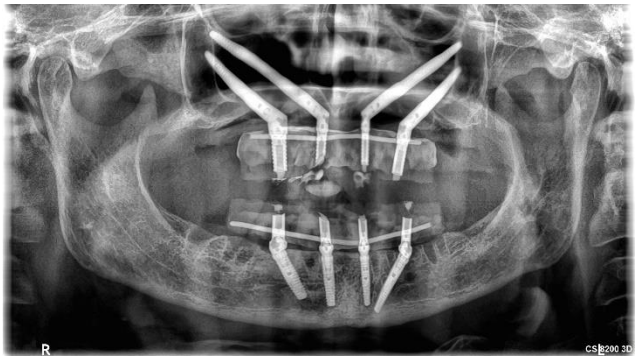

Fig. 9. *X-ray at 12-month follow-up.*

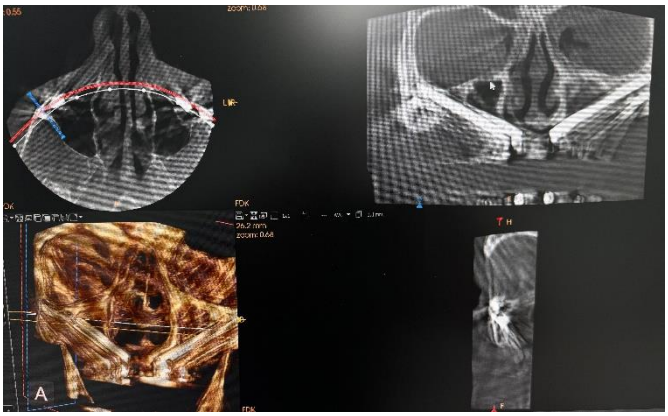

Fig. 10. *CBCT at 12-month follow-up.*

Case 2

P.S., a 69-year-old non-smoker female came to our Clinic complaining about her smile. She was almost without teeth (Fig. 11-18). After careful examination, a full arch rehabilitation using zygomatic implants was performed. The prosthesis was delivered immediately after the intervention, and post-delivery was uneventful.

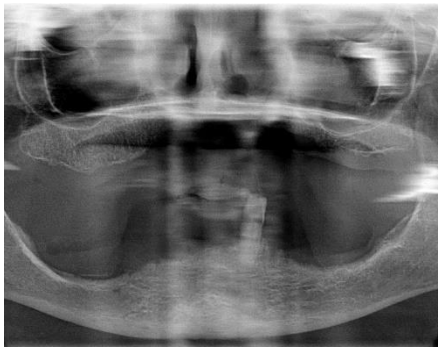

Fig. 11. *Pre X-ray.*

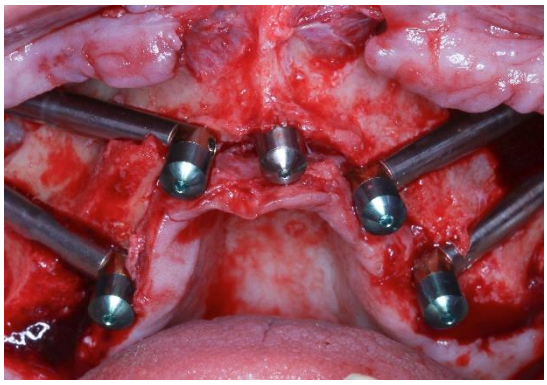

Fig. 12. *Zygomatic implants frontal view.*

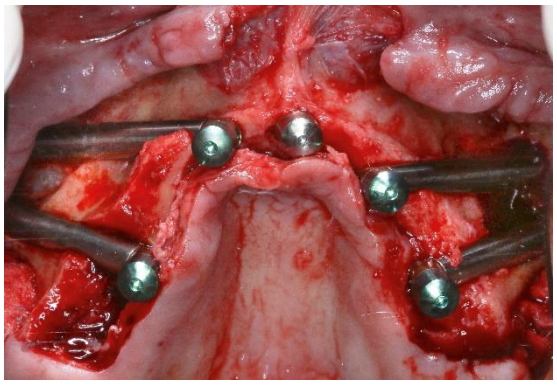

Fig. 13. *Zigomatic implant occlusal view.*

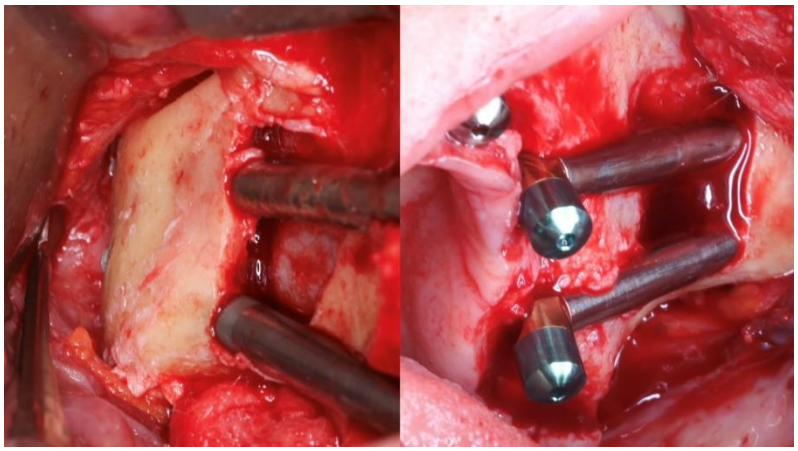

Fig. 14. *Details of bicortical zigomatic bone.*

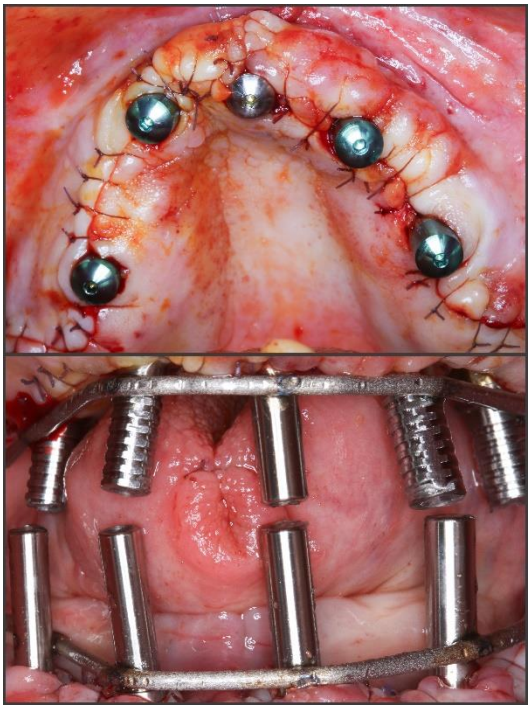

Fig. 15. *Soft tissue management and intraoral welding.*

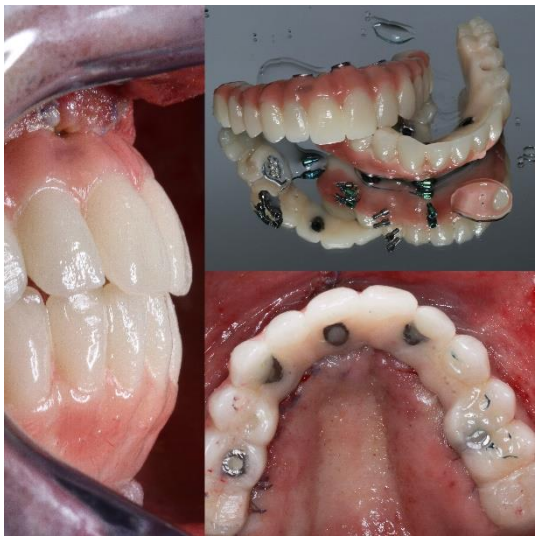

Fig. 16. *Durable prosthesis.*

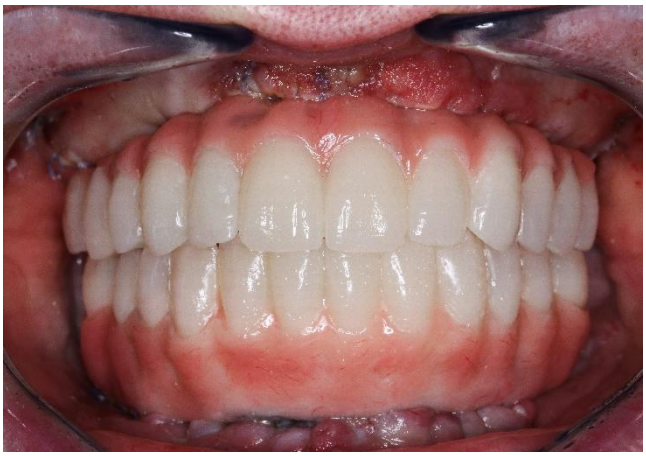

Fig. 17. *Delivery of prosthetic full arches.*

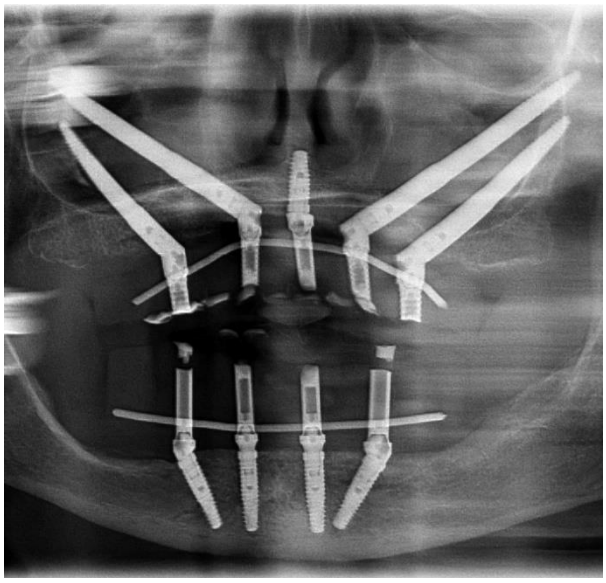

Fig. 18. *Twelve-month RX follow-up.*

Finally, a prosthesis was delivered Then the MUA are positioned, and intraoral welding is performed after a 1st intention sutures around healing pillars; the impression is taken for the prosthesis, and the prosthetic durable device is delivered by the afternoon. In addition, a Toronto Bridge on 4 implants was performed in lower jaw.

Case 3

M.M., a 58-year-old female patient who is a smoker, came to our Clinic complaining about her smile. She was edentulous (Fig. 19-30). After careful examination, a full arch rehabilitation using zygomatic implants was performed, and a Toronto Bridge on 4 implants was carried out in the mandible. The prosthesis was delivered immediately after the intervention, and post-delivery was uneventful.

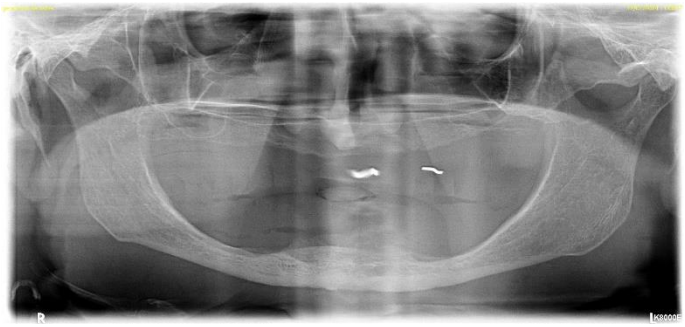

Fig. 19. *Pre X-ray.*

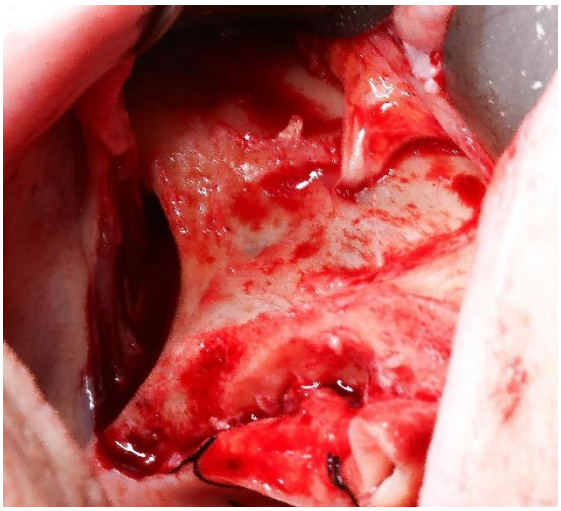

Fig. 20. *Right zygomatic bone exposed.*

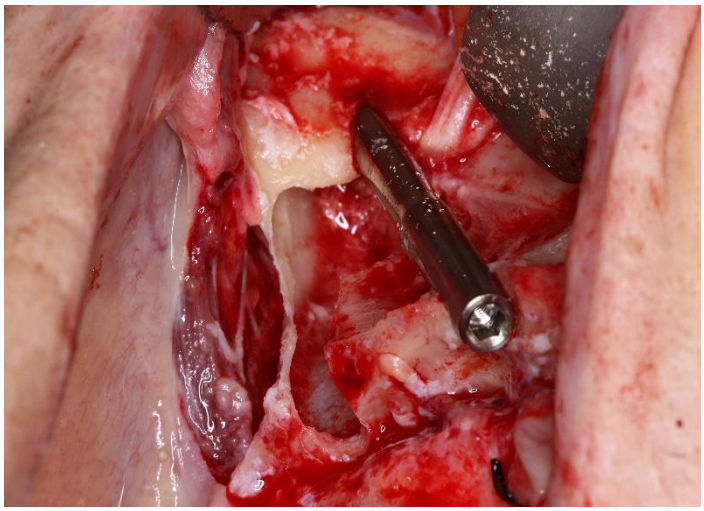

Fig. 21. *Right medial zygomatic implant inserted.*

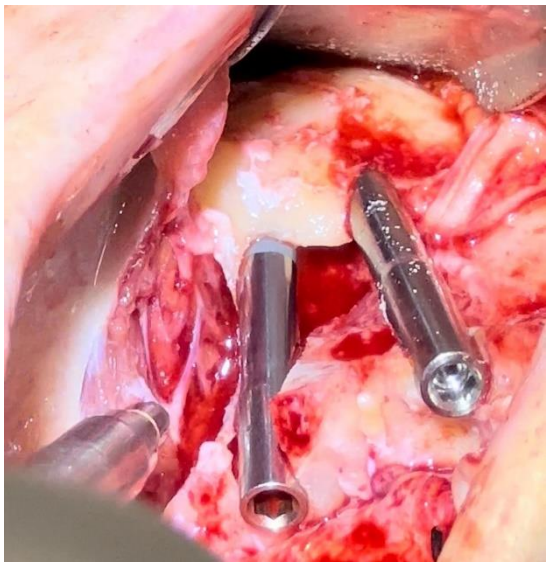

Fig. 22. *Right hemimaxilla with 2 Zis.*

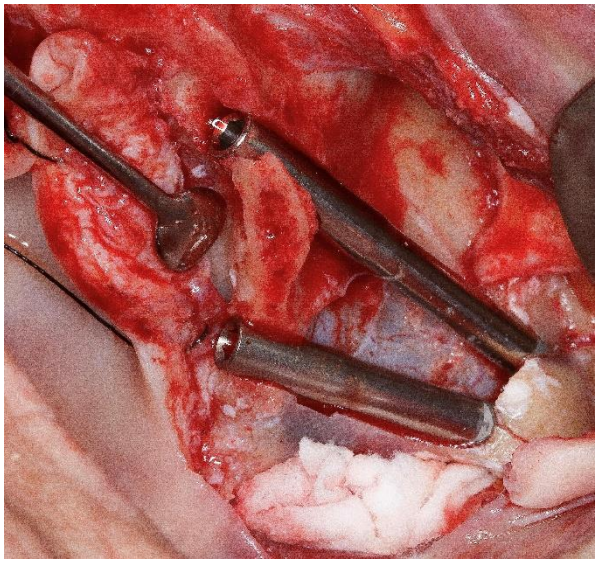

Fig. 23. *Left hemimaxilla with 2 ZIs.*

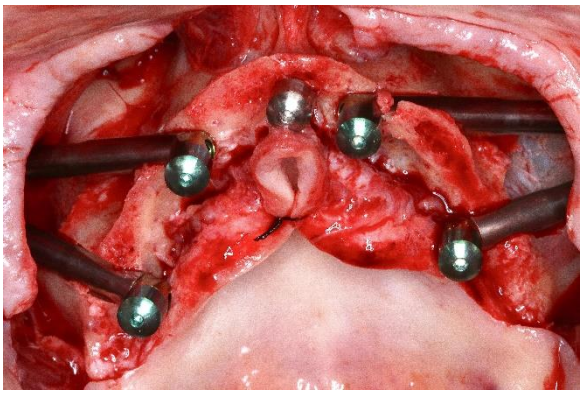

Fig. 24. *Implants of 4 ZIs positioned plus 1 standard implant in Medline under anterior nasal spine.*

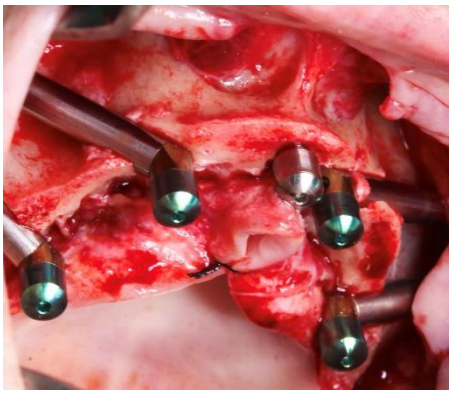

Fig. 25. *Lateral view.*

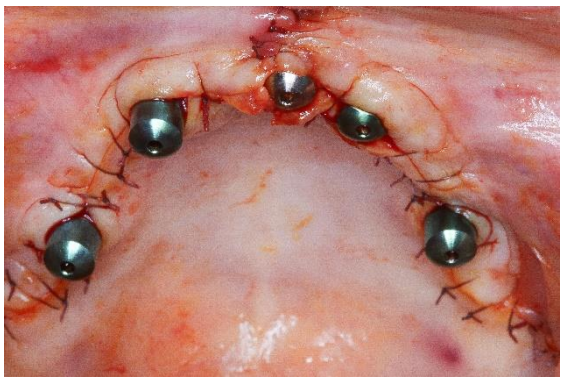

Fig. 26. *Suture.*

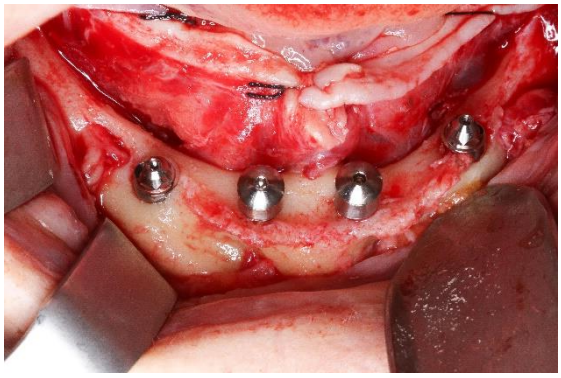

Fig. 27. *Lower jaw with 4 implants inserted.*

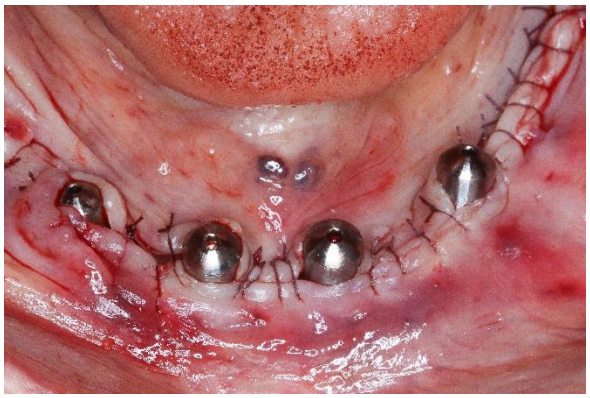

Fig. 28. *Lower jaw suture with mucosa sutured.*

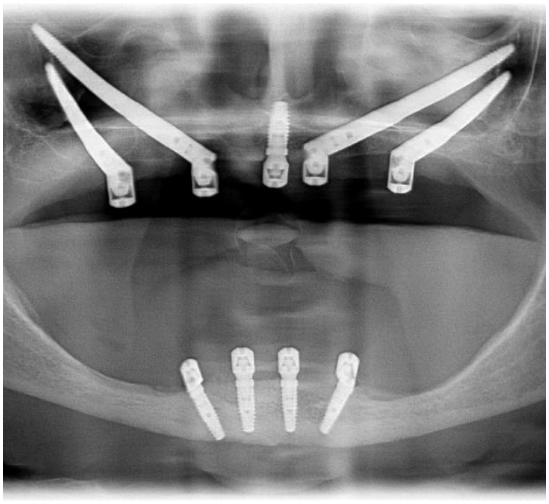

Fig. 29. *Post-operative X-ray.*

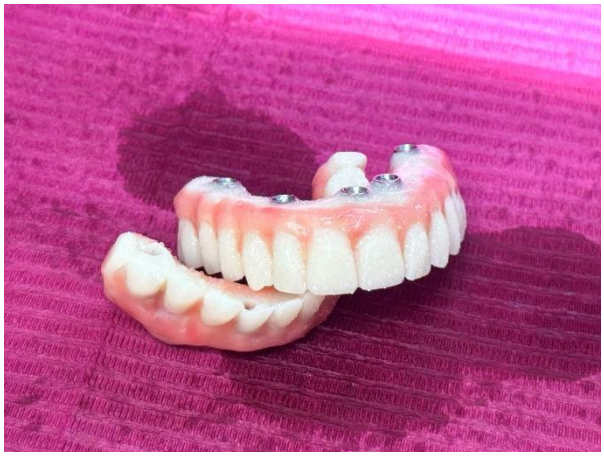

FIG. 30. *Prosthesis.*

DISCUSSION

The placement of ZI has emerged as a transformative solution for individuals with severe maxillary atrophy. Severe maxillary atrophy, characterized by extensive bone resorption in the upper jaw, is a primary indication of ZI. The assessment of atrophy severity through imaging techniques, such as cone-beam computed tomography (CBCT), guides clinicians in determining the appropriateness of ZI for a given patient. Patients with insufficient bone volume for traditional implant placement due to atrophy are ideal candidates for ZI. These implants bypass the need for bone grafting, providing a more efficient solution.

Computer-planned implant insertion is a procedure well established. Advancements in guided surgery and virtual planning tools enhance precision in patient selection. Virtual simulations allow for meticulous preoperative assessment, contributing to improved outcomes. Varghese et al. (6) reviewed prosthetic and zygomatic implant success of treating severe maxillary resorption with prostheses supported by 4 ZI. All prostheses were immediately loaded with acrylic resin interim prostheses replaced by a definitive prosthesis, which consisted of overdentures retained by bar splinting (n=2), metal bar-reinforced prostheses (n=2), fixed screw-retained acrylic resin prostheses (n=34), and screw-retained titanium prostheses with ceramic or acrylic resin teeth (n=75).

Technical complications of ZI included mobility associated with a machined surface and fracture of the abutment screw. The most common prosthetic complications reported were fracture of the definitive prosthesis and loss of the interim prosthesis subsequent to the failure of at least one ZI. The results showed that prostheses supported by quad ZIs displayed an overall success of 100%, whereas ZI showed a survival rate of 98% with minimal implant failures and few complications.

Fan et al. (7) investigated the accuracy of ZI placement using dynamic computer-aided surgery (d-CAIS), static computer-aided surgery (s-CAIS), and a free-hand approach in patients with severe atrophic edentulous maxilla and/or deficient maxilla. There was strong evidence of differences in the average entry, apex, and angular deviation between the navigation, surgical guide, and free-hand groups (the last being the worst). Using d-CAIS and modified s-CAIS for ZI surgery has shown clinically acceptable outcomes regarding average entry, apex, and angular deviations. The maximal deviation values were predominantly observed in the conventional s-CAIS. Surgeons should be mindful of potential deviations and complications, using different guide approaches, regardless of the decision-making process.

Ramezanzade et al. (8) reviewed the accuracy and complications (including failure) of dynamic navigation in placing ZI. The authors concluded that the application of dynamic navigation systems is a reliable technology for ZI placement, especially in difficult cases with a history of maxillary deficiency.

One notable advantage of ZI is the ability to provide immediate and efficient rehabilitation for patients with severe maxillary atrophy. Unlike traditional implant procedures that may require extensive bone grafting and prolonged healing periods, ZI offers a streamlined approach. Avoiding grafting procedures significantly reduces treatment time, allowing for the immediate placement of prostheses and rapid restoration of oral function and aesthetics. The avoidance of bone grafting and the ability to perform immediate loading contributes to a reduction in overall treatment complexity. ZI simplifies the rehabilitation process for patients with severe maxillary atrophy, making it a more accessible and efficient option. This reduction in treatment complexity is particularly beneficial for individuals who may be hesitant about undergoing extensive surgical procedures.

Polido et al. (9) investigated the indications for placement of ZI to rehabilitate edentulous maxillae. ZI indications were extreme bone atrophy or deficiency secondary to different factors. The quad zygoma concept (two ZI bilaterally placed and splinted) was applied to 107 patients, the classic zygoma concept (one zygomatic implant bilaterally placed and splinted to standard anterior implants) was used in 88 patients, and the unilateral concept (one zygomatic implant on one side, splinted with one or more conventional implants) was employed in 14 patients. The authors concluded that the main indication for using ZI was extreme maxillary bone atrophy, resulting from many factors. The definition of "extreme bone atrophy" is not uniquely defined in each paper.

Tuminelli et al. (10) systematically reviewed the outcome of immediately loaded ZI. They found that immediately loading ZI to restore the severely atrophic maxilla presents a viable alternative for the treatment of the

atrophic maxilla. Lorusso et al. (11) evaluated the survival rate of ZI in conjunction with regular fixtures for maxillary rehabilitation. There was a similar implant survival rate between zygomatic and premaxilla regular implants.

Sáez-Alcaide et al. (12) assessed the effect of rehabilitation with ZI on patient's quality of life. General findings of this systematic review showed substantial increases in oral health-related quality of life among patients restored with ZI and high scores in terms of general satisfaction, especially in chewing ability and esthetics. Brennand Roper et al. (13) performed a systematic review on the long-term survival rates of ZI. ZI success, prostheses survival and success, sinus pathology, and patient-reported outcomes were also investigated. They found a mean follow-up period of 75.4 months. The mean survival of ZIs was 96.2% at 6 years. Mean survival for delayed loading was 95% and 98.1% for immediate loading. The mean ZI success was 95.7%. Mean prosthesis survival was 94%. Sinusitis prevalence was 14.2% at 5 years. Consequently, the Authors concluded that ZIs have long-term survival comparable to conventional implants. Immediate loading showed a statistically significant increase in survival over delayed loading. Prosthesis survival was similar to prostheses supported by conventional implants, but with similar complications. Sinusitis was the most frequently encountered biological complication.

ZI has revolutionized oral rehabilitation, particularly in cases of severe maxillary atrophy. However, like any surgical procedure, zygomatic implant placement is not without potential complications. One notable concern in zygomatic implant surgery involves potential sinus-related complications. These can range from sinus membrane perforation during implant placement to postoperative issues such as sinusitis.

Chrcanovic et al. (14) investigated the most common complications related to ZI surgery. They analyzed thirty-seven studies. Postoperative complications reported were as follows: 70 cases of sinusitis, 48 of soft tissue infection, 15 of paresthesia, and 17 cases of oroantral fistulas. However, this number may be underestimated since most of the studies did not mention the presence or absence of these complications. Most ZI failures were detected at the abutment connection phase (6 months after implant placement surgery) or before. The cumulative survival rate over 12 years was 96.7 %.

Chrcanovic et al. (15) assessed the survival rate of ZI and the prevalence of complications based on previously published studies. Sixty-eight studies comprised 4,556 ZIs in 2,161 patients with 103 failures. The 12-year cumulative survival rate was 95.21%. Most failures were detected within the 6-month postsurgical period. Studies that exclusively evaluated immediate loading showed a statistically lower ZI failure rate than studies evaluating delayed loading protocols. The probability of presenting postoperative complications with ZIs was as follows: sinusitis, 2.4%; soft tissue infection, 2.0%; paresthesia, 1.0%; and oroantral fistulas, 0.4%. However, these numbers might be underestimated because many studies failed to mention the prevalence of these complications.

Molinero-Mourelle et al. (16) analyzed the most frequent surgical complications associated with the use of ZI. Of the most frequent surgical complications, sinusitis (3,9%) and failure in osseointegration (2.44%) are highlighted. Lan K et al. (17) investigated the postoperative complications and outcome (implant survival) of quad ZI inserted in patients with edentulism and severely atrophic maxillae. The incidence rates of complications were as follows: sinusitis 12%, malposition and surgical guiding failure 11%, local infection/injury 10%, and prosthetic complications 5%. The implant survival rate ranged between 95.8% and 100%. Quad ZI inserted in patients with severely atrophic edentulous maxillae have a high implant survival rate, but the incidence of complications should not be underestimated.

Tavelli et al. (18) evaluated the survival and complication rate of ZI, assessing factors (such as surgical technique, surgical/restorative plan, population, study design, and characteristics, etc.) associated with these outcomes. The mean survival rate among studies was about 98%. The survival rate was neither associated with the surgical technique nor the surgical/restorative plan. Forty-eight articles reported data on complications related to ZI, with labial laceration, orbital cavity penetration, hematoma, epistaxis, maxillary sinusitis, infection, and oro-antral communication being among the most common adverse events. A lower incidence of maxillary sinusitis was observed for ZI placed using the extra sinus approach compared to the other surgical techniques. The incidence of maxillary sinusitis and oro-antral communications were less likely in "recent" vs "less recent" studies.

Gabriele et al. (19) investigated the probability of postoperative complications at both the implant and patient level for each of the four surgical techniques for zygomatic implant (ZI) placement: Brånemark, sinus slot, extra sinus, and extra maxillary. They concluded that ZI placement was demonstrated to be a reliable technique for the rehabilitation of severely atrophic maxillae, irrespective of the surgical technique evaluated. Accurate case and surgical protocol selection is paramount to reducing technique-related postoperative complications.

Kämmerer et al. (20) assessed the outcome of ZI and complications of the original surgical technique (OST) and an Anatomy-Guided approach (AGA) in the placement of ZI in patients with severely atrophic maxillae. They verified that placing ZI in severely atrophic edentulous maxillae rehabilitation with the OST and AGA is associated with a high implant survival rate and surgical complications within a minimum of 6 months follow-up. Complications, including sinusitis and soft tissue infection around the implant, are the most common. The utilization of immediate loading protocol

is more observed in AGA than in OST. ZI can be installed inside the maxillary sinus, called instrasinus zygomatic implant (IZI), or outside the maxillary sinus (EZI), depending on the surgery technique. Moraschini et al. (21) observed no statistically significant between ZI and CI in prospective studies. The biological complications most related to ZI was sinusitis, followed by infection and oroantral communication. The authors concluded that ZI has a high long-term survival rate (96.5% with a mean of 91.5 months of follow-up), showing no significant difference compared to conventional implants. The most prevalent biological complication is sinusitis, commonly in the IZI technique.

Rigorous preoperative assessment of maxillary sinus anatomy, aided by advanced imaging modalities like cone-beam computed tomography (CBCT), is crucial. Additionally, employing careful surgical techniques, such as the use of proper instruments and grafting materials in the presence of sinus perforation, can mitigate these complications. The proximity of ZI to critical neurovascular structures raises the risk of nerve damage during surgery. The infraorbital nerve and other branches in the maxillary region must be carefully considered to prevent sensory disturbances or paresthesia.

Meticulous surgical planning, guided surgery technologies, and intraoperative monitoring contribute to minimizing the risk of nerve-related complications. Close collaboration between oral surgeons and neurosensory specialists is essential in addressing and managing postoperative sensory issues. While ZI generally exhibits high success rates, various factors can contribute to implant failure. Inadequate primary stability, poor bone-implant contact, and biomechanical challenges may compromise the long-term success of ZI. Thorough preoperative planning, including precise bone quality and quantity assessment, is crucial. Postoperative care, regular follow-ups, and patient compliance with oral hygiene protocols contribute to identifying and addressing potential issues early on. Infection and peri-implantitis are potential complications that can compromise the success of ZI. Maintaining meticulous oral hygiene, both preoperatively and postoperatively, is crucial in preventing bacterial colonization. Regular professional cleanings and patient education on oral care practices contribute to reducing the risk of infection. In cases where peri-implantitis occurs, prompt diagnosis and intervention, including debridement and antibiotic therapy, are essential for implant preservation.

CONCLUSIONS

The advantages of ZI make them a compelling solution for individuals facing the challenges of severe maxillary atrophy and complex oral rehabilitation scenarios. The streamlined treatment process, elimination of bone grafting, increased stability, and versatility in addressing diverse clinical situations collectively position ZI as a transformative option in implant dentistry. The surgical procedures of ZI involve a meticulous and multidisciplinary approach, and a thorough understanding of potential complications and considerations is paramount. The meticulous assessment of anatomical factors, careful surgical planning, and ongoing postoperative care contribute to the success of ZI procedures. Studies consistently report high implant survival rates for ZI.

The robust anchorage in the zygomatic bone contributes to the stability of these implants. Research spanning a decade indicates survival rates well above 90%, showcasing the durability of zygomatic implant-supported prostheses. Long-term follow-up studies focus on implant survival and the functionality and performance of zygomatic implant-supported prostheses. Patients often experience restored oral function, including improved masticatory efficiency and speech. The longevity of prosthetic rehabilitation contributes significantly to the overall success and satisfaction of ZIs. The aesthetic outcomes of zygomatic implant-supported prostheses are integral to patient satisfaction.

Long-term studies assess the stability of soft tissues, including gingival contours and lip support, to ensure that the aesthetic benefits achieved immediately after surgery are maintained over time. Complications are possible, but precise technical procedures, postoperative monitoring, and long-term follow-up of patients with timing re-calls reduce risks related to ZI procedures.

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Cohort Study

PREVALENCE OF STILLMAN'S CLEFTS AMONG ALBANIAN YOUNG ADULTS

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ABSTRACT

Stillman's clefts are among the least studied mucogingival defects that might compromise the esthetic and periodontal health of the affected teeth. The aim of the present study is to collect data on the prevalence of this defect among young adults in Albania. Participants were dental school students recruited for oral examination and detection of Stillman's clefts, with the use of discoloring solution for shallow initial clefts. One single operator performed the examination. All participants filled out a questionnaire to gather information on oral hygiene and local traumatic factors associated with Stillman's cleft. One hundred thirty dental students (77 females and 53 males) with an average age of 22.5 (21-28) ± 1.5 years participated in the survey. Stillman's clefts were identified as 9.2% of them. A higher association was observed with the use of a medium toothbrush. No similar association was observed with the traumatic use of interdental floss. None of the participants with the defect presented symptoms. Overall, a prevalence of 9.2% was observed among young adults, with a slight tendency to be associated with medium toothbrush use.

KEYWORDS: *Stillman's cleft, prevalence, oral hygiene*

INTRODUCTION

Stillman's cleft is a mucogingival triangular-shaped defect found as a single or multiple defect mainly located on the buccal surface of a root. It was first described as a recession-related occlusal trauma (1); however, no studies are confirming this association. Until now, the etiology and pathogenesis of these defects remain uncertain. Hypotheses exist on chronic factors that ulcerate the epithelium and heal through the anastomosis of the external and internal epithelium in the gingival sulcus, creating a triangular defect (2). Based on the study mentioned above, when the anastomosis is not complete, the cleft is distinguished as a red cleft, and when epithelization is complete, the cleft is recognized as a white cleft.

Possible etiological factors are assumed to be inflammation (3), traumatic tooth-brushing, and the incorrect use of interdental floss (4). A higher incidence of gingival fissures was observed when medium-hard toothbrushes were used, and the occurrence increased with time (5).

Independent on the cause, if the fissure is red, patients are recommended to interrupt mechanical plaque removal and use CHX for at least 2 weeks, followed by proper instructions on oral hygiene measures after mouth rinse interruption (6). On the other hand, when treating the so-called white cleft, a surgical procedure aiming at transforming the cleft in a

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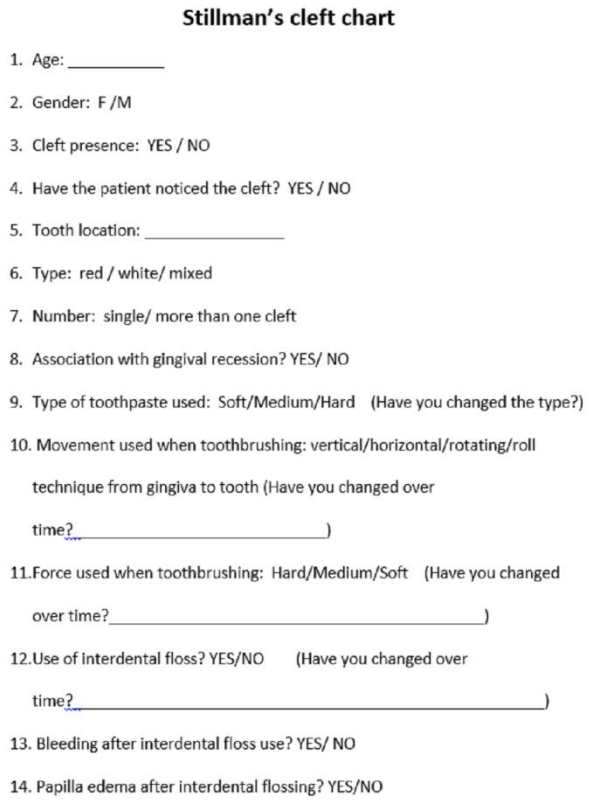
regular gingival recession and subsequently applying the same techniques as in this later lesion is needed (6). Among surgical techniques, the laterally moved, coronally advanced flap has been described as predictive in 5 years of follow-up (7).

Few evidence is available on this type of defect, mainly focused on their treatment. A histopathologic study has recently been conducted to better understand the nature of the clefts (8). Thus, the aim of the present study is to provide preliminary data on the prevalence of Stillman's defects among young adults.

MATERIALS AND METHODS

This study was approved by the Institutional Review Board (Ethic Committee) of Albanian University (protocol code 83 and date of approval 19 February 2016).

Participants were students from the dental university background examined after being informed of the purpose of data collection, without any specific inclusion/exclusion criteria from May 2016 and October 2016. Informed consent was obtained from all subjects involved in the study. A single experienced operator performed the clinical examination of the students. Before being examined, each student completed a specific questionnaire to collect general information and data on oral hygiene instruments and self-reported performance (Fig. 1).



Stillman's cleft chart

1. Age: _____
2. Gender: F /M
3. Cleft presence: YES / NO
4. Have the patient noticed the cleft? YES / NO
5. Tooth location: _____
6. Type: red / white/ mixed
7. Number: single/ more than one cleft
8. Association with gingival recession? YES/ NO
9. Type of toothpaste used: Soft/Medium/Hard (Have you changed the type?)
10. Movement used when toothbrushing: vertical/horizontal/rotating/roll technique from gingiva to tooth (Have you changed over time?_____)
11. Force used when toothbrushing: Hard/Medium/Soft (Have you changed over time?_____)
12. Use of Interdental floss? YES/NO (Have you changed over time?_____)
13. Bleeding after interdental floss use? YES/ NO
14. Papilla edema after interdental flossing? YES/NO

Fig. 1. *Questionnaire for oral hygiene measures and risk factors for Stillman's cleft.*

Clinical inspection was performed and aided by local discoloring solution (Lugol's solution) in case of doubts on diagnosis, particularly of small red clefts. Descriptive analysis was performed, and data was expressed as percentages.

RESULTS

In total, 130 students (77 females and 53 males) with an average age of 22.5 (21-28) participated in the study (Table I).

Table I. *Population characteristics and oral hygiene measurements distribution.*

Age	**22.5 (21-28)**				
Gender	Female	Male			
	77	53			
Type of toothbrush	Hard	Medium	Soft		
	2	99	29		
	Hard	Medium	Soft		
	4	114	11		
Type of toothbrushing movement	Vertical	Horizontal	Circular	Roll*	Mixed
	7	6	59	13	45
Use of interdental floss	84%				
Bleeding on flossing	38%				
Interdental papilla edema after flossing	4%				
Stillman's cleft presence	9.2%				

***Modified Bass technique.*

The Stillman's cleft was found in 9.2% of participants, equally distributed among females and males (Fig. 2). Half of them reported having been aware of the presence of a defect at the gingival level, some of which related its presence to bad habits or previous local surgery.

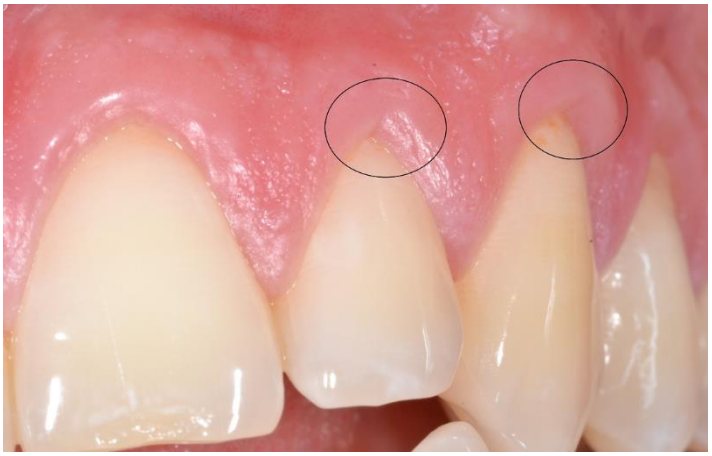


Fig. 2. *Stillman's clefts of one of the participants.*

All clefts were located buccally, mainly at the upper jaw (74%) and anterior region (53%), compared to the lower jaw and posterior region, respectively. The defect was present on a single tooth in 75% of cases. Among the 19 clefts, the majority were mixed clefts (47%), while 37% were red clefts, and the rest were present as white clefts, with only 5 being associated with gingival recession.

Overall, 76% of the participants used a medium toothbrush. Only 2 out of 130 students still used hard toothbrushes, but they were not associated with cleft formation. Participants with Stillman's cleft reported using soft (58%) and medium (42%) toothbrushes, with 71% of soft toothbrushes being former hard toothbrush users. The toothbrush was used with moderate force in 88% of the cases, according to individual perceptions of the force used. Only 3 out of 12 Stillman's cleft participants brushed hard, with one reporting to have changed to moderate force.

Interdental spaces were cleaned with interdental instruments by 84% of participants, prevalently being the interdental floss (99%). The trauma associated with the use of interdental instruments was retrospectively investigated with the reporting of bleeding or edema of the gingival papilla after instrument use. Among users, 41% reported either

bleeding or edema, or both of them. Among Stillman's cleft participants, 75% used interdental instruments, but only 44% reported associated bleeding.

All participants with Stillman's defect were asymptomatic and were reluctant when treatment was proposed, except for the oral hygiene instruction.

DISCUSSION

In fulfilling the aim of the study, data revealed a 9.2% prevalence of Stillman's fissure among young adults, with a similar distribution among genders. Unfortunately, the present data cannot be compared with other studies as no evidence was published previously. A higher association was observed with medium toothbrushes, but as a small population represents a limit of the study, these results should be interpreted cautiously. Similar results of association with medium brush were observed by Greggianin et al. 2013 (5). A factor that could have influenced the prevalence of gingival fissures is the fact that all participants were dental students in their third or fourth year. The information on oral hygiene instructions could have improved their self-performance of dental hygiene concerning the type of instruments and the correct use. The majority of participants using soft toothbrushes reported to have been former users of hard toothbrushes. If considering that a reversible (red) experimentally induced cleft takes almost 10 days to recover (5), a higher prevalence might have been expected if oral hygiene measures were not changed.

Interestingly, none of the participants wanted to treat the defect apart from receiving the appropriate prevention instruction. The authors assumed this could be related to a lack of symptoms. The reluctance to surgical treatment emphasizes the importance of preventing and treating reversible forms of the cleft. Zucchelli has proposed a systematic and rigid protocol of chemical plaque control with 0.12% CHX while suspending toothbrushes and interdental floss (6). For the first 15 days, CHX is used 3 times a day, after which a super-soft toothbrush with the roll technique is introduced; mouth rinsing is reduced to 2 times daily for the next 15 days. After the first month, the patient continues the mouth rinse once daily for another month in association with a soft toothbrush. Only after two months can the patient start using the medium toothbrush and the interdental floss.

Classifying gingival fissures among mucogingival defects, the treatment indication is assumed to follow the same rationale, particularly for white clefts: esthetics, hypersensitivity, recurrent plaque retention, and root caries/abrasion (6). In the case of clefts, being treated as a narrow deep recession, plaque retention might be considered as the main cause of treatment. From a preliminary histological study, cleft from healthy periodontal tissues showed histological features of acute with predominantly T small lymphocytes in correspondence of the cleft and of mild gingivitis with few plasma cells around the cleft in apparent clinically healthy gingival (8). From the same study, periodontal disease-treated associated cleft showed histological features similar to chronic gingivitis or mild periodontitis with a predominantly B cells response with only a few plasma cells and chronic scarring of lamina propria (8). Accordingly, clefts that are clinically healthy in patients having no complaints should be reconsidered for treatment, particularly when recurrent retention of plaque and subsequent further progression of the fissure toward the oral mucosa is noticed.

One of the students reported the creation of the defect after the healing of surgery extended to the anterior area. Iatrogenic causes of this type of defect have not been reported previously, although following the pathogenesis of cleft formation through epithelization, it might be possible that during the healing of the incision if both flaps are not properly positioned, epithelization might occur prior to connective tissue formation.

To the author's knowledge, no previous studies have been conducted on the prevalence of Stillman's cleft. Within the limits of sample size and sample selection, the data suggest further studies could be useful on the burden this cleft presents to the patients. No conclusion could be stated on the association of toothbrushes and traumatic use of interdental floss with Stillman's cleft, but the authors suggest further studies could be useful.

CONCLUSIONS

In conclusion, Stillman's cleft presented a prevalence of 9.2% in a population when proper oral hygiene is assumed to have been corrected. A higher association was noticed with a medium brush, but none of the participants reported symptoms or complaints regarding the defect.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest

The authors declare no conflicts of interest.

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Case Report

MODIFICATION OF THE OCCLUSION OF A REMOVABLE PROSTHESIS IN THE ORAL CAVITY IN AN ONCOLOGY PATIENT: A CASE DESCRIPTION

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ABSTRACT

The evolution of prosthetic dentistry with the help of new technologies has made it possible to resolve clinical cases by reducing complications and the timing of interventions. The use of materials and tools present in a dental practice allows you to intervene immediately and expand interventions on patients' prostheses in extreme cases. The presented case of the occlusal modification of a removable prosthesis was solved with a traditional technique in a single appointment, reducing the discomfort of the fragile patient.

KEYWORDS: *removable prosthesis, acrylic resin, occlusion, bisphosphonates, oncology patient*

INTRODUCTION

Prosthetic dentistry is the branch of dentistry that deals with the restoration and maintenance of masticatory functions by re-establishing the patient's oral health. The correct relief of the occlusal contacts on models mounted in the articulator is of fundamental importance in the construction of a dental prosthesis. The evolution of technologies in the dental field has made it possible to create even complex prosthetic products, facilitating the dentist in planning and carrying out prosthetic rehabilitation by reducing work times and better managing patient compliance (1-3).

New technologies have also had exponential growth in the pandemic period with all the precautions of single-use, avoiding some laboratory steps, and reducing visits to the clinic (4). The factors that must be considered for prosthetic rehabilitation are mechanical, biological, and psychological and must be understood and adapted for personalized treatment to obtain pleasant aesthetic results (5, 6). It is precisely the biological factors in adults and elderly subjects that often influence therapeutic choices, eliminating the possibility of using implant systems that would improve the masticatory biomechanics and the psychological state of the patient who, as a consequence, finds himself undertaking therapies aimed at the accurate maintenance of the teeth residues to have greater occlusal stability (7-9).

Systemic factors can be decisive in the choice of oral rehabilitation, such as neoplasms based on the site of onset, grade, and stage; surgical, chemo or radiotherapy therapy can be chosen, or a combination of these in a synchronous manner, as well as syndromes or lesions high-risk oral infections influence the dentist's choice in proposing a solution for the patient (10-15). The management of cancer patients presents multiple challenges, particularly when these patients take bisphosphonates (16, 17). Although widely used as these drugs inhibit bone resorption, they can significantly impact oral health by interfering with the healing response after dental surgery (18-20). Therefore, It is necessary to carefully

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evaluate the medical history and pharmacological therapy before prosthetic rehabilitation on patients at risk, suggesting a multidisciplinary approach to medical oncologists and other specialists.

Completely edentulous cancer patients often need to have a dental prosthesis or, if they have been edentulous for many years, to replace the old, worn prosthesis with a new one to have greater stability and comfort. Therefore, in addition to the oral clinical examination, it is necessary to evaluate the medical history and current pharmacological therapy (21, 22). The case we presented concerns a chairside operation to re-establish the correct occlusion in an oncology patient with pulmonary metastases who, in addition to chemotherapy and radiotherapy, takes bisphosphonates.

CLINICAL CASE

Presentation of the case

A 63-year-old male patient comes to our observation complaining of chewing difficulties. The medical history highlighted a previous operation in March 2023 on the colon for cancer and the presence of a lung tumor, which he treated with chemo and radiotherapy in addition to taking bisphosphonate drugs. On intra-oral examination, the patient had partial upper edentulism; only 1.1 – 2.1 – 2.2 were present, and a total lower edentulism. The patient appeared visibly exhausted, very thin, and weak. It was of fundamental importance to speak to his wife, who accompanied him as she reported that although the prostheses were new, made about 14 months ago, he was not wearing them because he was unable to chew the soft food, and the oncologist had suggested redoing or adjusting it to allow correct nutrition.

Planning of the intervention

The prostheses showed no lesions or superficial alterations, were inserted into the oral cavity, did not wobble, and adhered perfectly; the residual elements were visibly structurally compromised. The oncologist's opinion provided by the patient categorically prohibited any surgical or other intervention (root canals) on the remaining teeth. The patient only requested to modify the prostheses as quickly as possible, avoiding multiple appointments. Therefore, in agreement with the patient, it was decided to modify the occlusion using a technique that involves detaching the elements that are not included to reposition them correctly in occlusion directly in the chair to avoid a subsequent appointment.

Modification of the occlusion

The intervention to modify the occlusion involved using pink self-polymerizing acrylic resin, the Fox plane, the straight laboratory handpiece with the relevant cutters, and polishing rubbers as materials.

The choice of the occlusal modification of the prostheses fell on the lower one since the upper prosthesis, evaluated with the Fox plane, did not present both frontal and lateral alterations. The elements, therefore, to be repositioned in occlusion were 4.5-4.6-4.7. We initially removed the elements under occlusion using the straight handpiece with a ball bur, carefully removing them all together (Fig. 1).

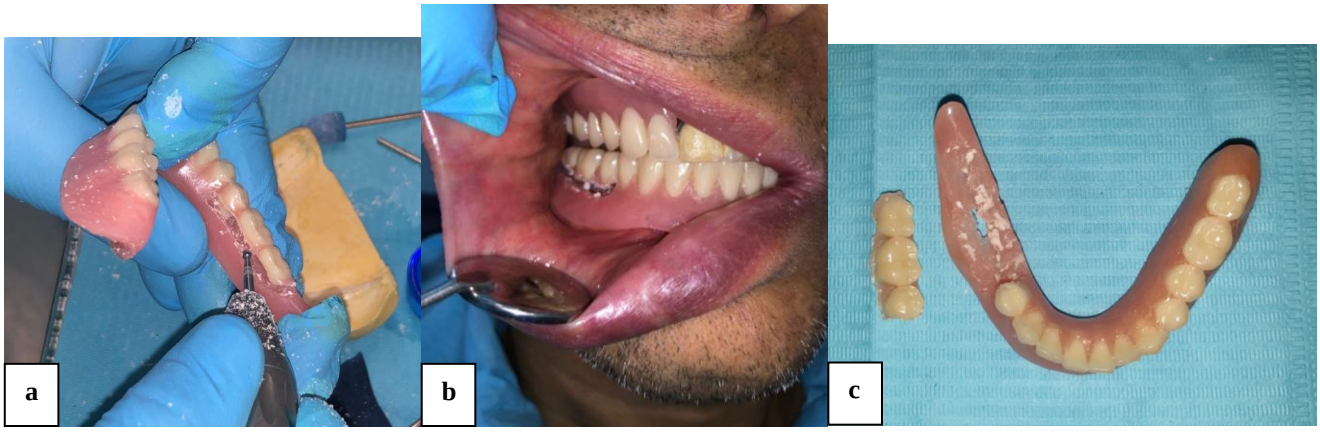

Fig. 1. ***a****): Lingual view of the sulcus for the removal of 4.5-4.6-4.7;* ***b****): Intra-oral view of the incorrect occlusion of the lower elements;* ***c****): Detachment of the joined elements 4.5-4.6-4.7.*

The phase following the detachment of the elements was to prepare the acrylic resin to position it in a rubbery state between the base and the detached teeth, being careful not to create steps between 4.4 and 4.5, placing everything in the patient's mouth, asking him to close slowly to check the occlusion. Once the polymerization was completed, the excess resin was removed and finished with polishing rubbers (Fig. 2). The result is immediate and visible even for the patient who immediately perceives the posterior contacts, the only small defect of this technique is the color of the self-polymerizing acrylic resin (Fig. 3).

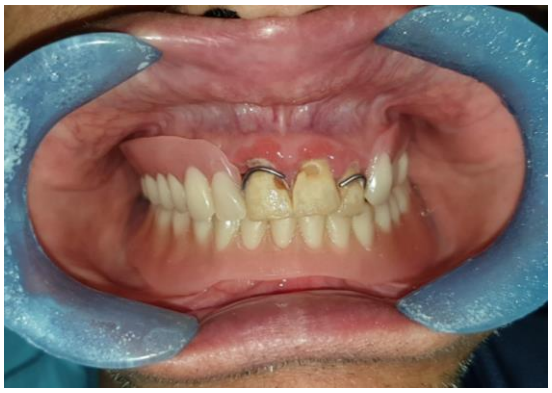

Fig. 2. *Correct prosthesis in occlusion.*

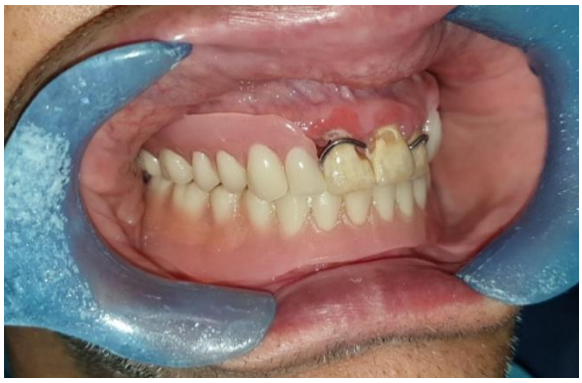

Fig. 3. *Repositioning of elements 4.5-4.6-4.7 shows the slightly lighter color of the acrylic resin inserted for the occlusal modification.*

DISCUSSION

Over the last twenty years, the prevention of oral pathologies and the continuous prevention campaigns carried out by various trade associations have played an important role in raising patient awareness. This result can be seen as the number of young people going to the dentist has increased at the slightest discomfort or at the slightest change in color or stain on the teeth. Caries and periodontal disease are the most prominent causes of partial or total edentulism. New technologies help us a lot in the prevention and rehabilitation of the oral cavity by significantly reducing any extraction surgery, the healing times of the tissues, and the choice of the type of prosthesis to be performed, obtaining results that increasingly lead to the maintenance of one's teeth or implants (23, 24).

Leonida et al., in recent works, have demonstrated how the use of synthetic melatonin in powder form and with new techniques in complex cases or distal edentulism, through the use of new techniques the surgical procedure for bone regeneration becomes more predictable, obtaining excellent results for rehabilitation implant-prosthetics (25, 26). One of the problems that creates concern and difficulty in choosing rehabilitation in the field of implant prosthesis is the use of bisphosphonates (27-29). The association between oncological therapy and the use of bisphosphonates directs the dentist toward removable prosthetic rehabilitation, which allows the most rigid control of the oral tissues. In the case we treated, the two therapies, oncological and bisphosphonates, were in place, and the new technologies would not have given the right support in a short time. A new technology that could be used in cancer patients who are also taking bisphosphonates or monoclonal antibody therapy is the use of a laser in reducing pain or adjuvant in periodontal therapies.

Caccianiga et al., in recent studies, have demonstrated how photodynamic therapy and laser can have positive results in improving the pain perceived by the patient and in bacterial decontamination in cases of peri-implantitis (30, 31). The majority of adult and elderly cancer patients who present total or partial edentulism compensated with inappropriate removable prostheses, often also due to the pandemic effect of COVID-19 or objective difficulties, tend to postpone the need for treatment for prosthetic dental problems, increasingly reducing using the prosthesis for chewing and wearing it only for aesthetics (32). The clinical case presented showed, in addition to the chewing difficulties, also an important systemic condition that influenced his choice to contact the dentist. Using materials and equipment easily available in any dental practice has allowed us to solve the occlusal problem quickly without inconveniencing the patient by leaving the prosthesis or scheduling another delivery appointment.

Aesthetics in frail subjects wearing removable prostheses are also important because they affect their communication and social aspects (33).

CONCLUSIONS

In conclusion, we can state that although new technologies help us in procedures by also reducing the processing times of prosthetic products, some traditional techniques are quicker and more immediate when the systemic conditions of the fragile patient are important.

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki.

Declaration of informed consent

The patient signed the written consent form, which is required by law, for the modification of the prosthesis, which also includes the iconography.

Conflict of interest

The authors declare that there was no conflict of interest in the study.

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