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).

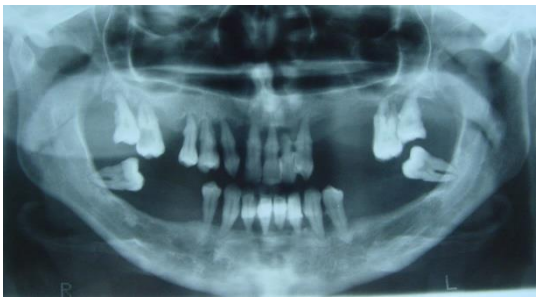

Fig. 1. *Initial radiological picture.*

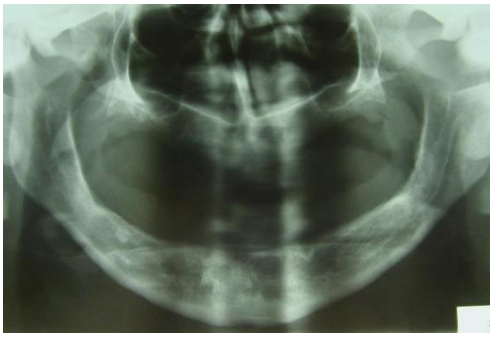

Fig. 2. *T_0 - pre-operative OPT, 60 days after teeth extraction.*

Fig. 3. *Iliac harvest.*

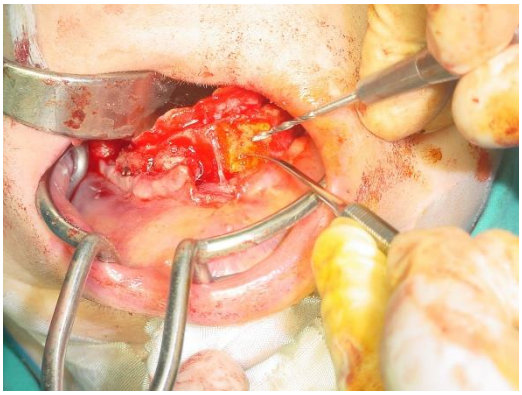

Fig. 4. *Fixation of the bone graft at the maxillary level.*

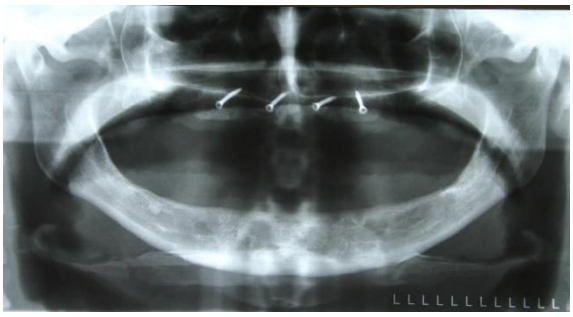

Fig. 5. *T_1 - OPT after apposition of bone grafts.*

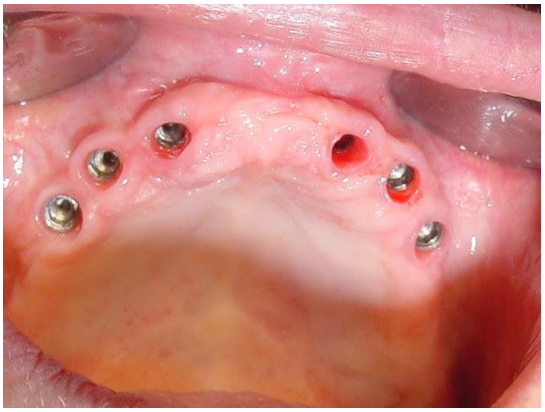

Fig. 6. *Insertion of the fixtures.*

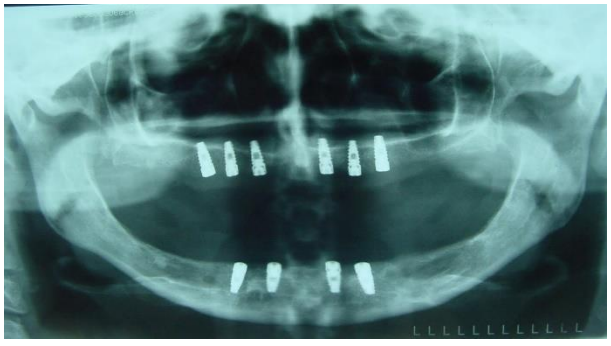

Fig. 7. *T_2 - control OPT.*

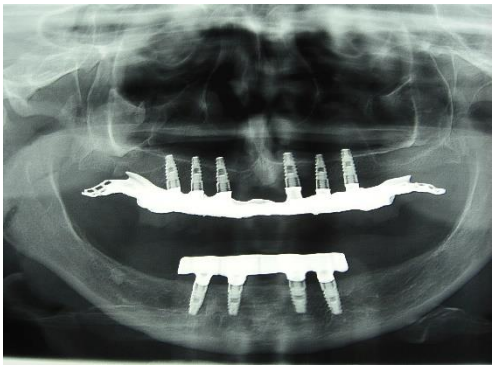

Fig. 8. *T_3 - control OPT.*

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.

REFERENCES

1. Baldoni M, Annoni G, Monai D, Carini F. Implant prosthetic solutions in the old patient with serious bone atrophy. *Giornale di Gerontologia*. 2006;54:227-232.
2. Baldoni A de O, Chequer FMD, Ferraz ERA, Oliveira DP de, Pereira LRL, Dorta DJ. Elderly and drugs: risks and necessity of rational use. *Brazilian Journal of Pharmaceutical Sciences*. 2010;46(4):617-632. doi:https://doi.org/10.1590/s1984-82502010000400003
3. Baldoni M, Simion M. *Odontoiatria Geriatrica*. Farmitalia Carlo Erba; 1993. https://www.abebooks.it/Odontoiatria-Geriatrica-Baldoni-Marco-Massimo-Simion/30089472864/bd
4. Bartold PM. Gerodontology - what is it and what does it mean to us? *Australian dental journal*. 2001;46(4):235.
5. Frost HM. The mechanostat: a proposed pathogenic mechanism of osteoporoses and the bone mass effects of mechanical and nonmechanical agents. *Bone and Mineral*. 1987;2(2):73-85.
6. Frost HM. Perspectives: The role of changes in mechanical usage set points in the pathogenesis of osteoporosis. *Journal of Bone and Mineral Research*. 2009;7(3):253-261. doi:https://doi.org/10.1002/jbmr.5650070303
7. Birkenfeld L, Yemini M, Kase NG, Birkenfeld A. Menopause-Related Oral Alveolar Bone Resorption. *Menopause*. 1999;6(2):129-133. doi:https://doi.org/10.1097/00042192-199906020-00009
8. Aldrige JI, Lester V, Watts PL. Single blind studies of the effects of improved periodontal health on metabolic control in type 2 diabetes mellitus. In: *Handbook of the Biology of Aging.* Van Nostrand Reinhold ; 1985:166-176.
9. Werning JW, Downey NM, Brinker RA, et al. The Impact of Osteoporosis on Patients with Maxillofacial Trauma.

Archives of Otolaryngology–Head & Neck Surgery. 2004;130(3):353-356. doi:https://doi.org/10.1001/archotol.130.3.353

10. Sanfilippo F, Bianchi AE. Osteoporosis: the effect on maxillary bone resorption and therapeutic possibilities by means of implant prostheses--a literature review and clinical considerations. *PubMed*. 2003;23(5):447-457.
11. Payne JB, Reinhardt RA, Nummikoski PV, Patil KD. Longitudinal Alveolar Bone Loss in Postmenopausal Osteoporotic/Osteopenic Women. *Osteoporosis International*. 1999;10(1):34-40. doi:https://doi.org/10.1007/s001980050191
12. Faber TD, Yoon DC, Service SK, White SC. Fourier and wavelet analyses of dental radiographs detect trabecular changes in osteoporosis. *Bone*. 2004;35(2):403-411. doi:https://doi.org/10.1016/j.bone.2004.03.002
13. Ruggiero SL, Mehrotra B, Rosenberg TJ, Engroff SL. Osteonecrosis of the jaws associated with the use of bisphosphonates: a review of 63 cases. *Journal of Oral and Maxillofacial Surgery*. 2004;62(5):527-534. doi:https://doi.org/10.1016/j.joms.2004.02.004
14. Pretzl B, Kim TS, Steinbrenner H, Dörfer C, Himmer K, Eickholz P. Guided tissue regeneration with bioabsorbable barriers III 10-year results in infrabony defects. *Journal of Clinical Periodontology*. 2009;36(4):349-356. doi:https://doi.org/10.1111/j.1600-051x.2009.01378.x
15. Zarb GA, Zarb FL. Tissue integrated dental prostheses. *Quintessence international (Berlin, Germany : 1985)*. 1985;16(1):39-42.
16. Wallace S, Froum S. Effect of Maxillary Sinus Augmentation on the Survival of Endosseous Dental Implants. A Systematic Review. *Annals of periodontology / the American Academy of Periodontology*. 2003;8:328-343. doi:https://doi.org/10.1902/annals.2003.8.1.328
17. 17.E.S. Tadjoedin, de J, Holzmann PJ, Kuiper L, Burger EH. Histological observations on biopsies harvested following sinus floor elevation using a bioactive glass material of narrow size range. *Clin Oral Implants Res*. 2000;11(4):334-344. doi:https://doi.org/10.1034/j.1600-0501.2000.011004334.x
18. Tadjoedin ES, De Lange GL, Lyaruu DM, Kuiper L, Burger EH. High concentrations of bioactive glass material (BioGran®
) vs. autogenous bone for sinus floor elevation. *Clinical Oral Implants Research*. 2002;13(4):428-436. doi:https://doi.org/10.1034/j.1600-0501.2002.130412.x
19. Queiroz TP, Hochuli-Vieira E, Aparecida M, Cristina D. Use of bovine bone graft and bone membrane in defects surgically created in the cranial vault of rabbits. Histologic comparative analysis. *PubMed*. 2006;21(1):29-35.
20. Thorwarth M, Schultze-Mosgau S, Kessler P, Wiltfang J, Schlegel KA. Bone Regeneration in Osseous Defects Using a Resorbable Nanoparticular Hydroxyapatite. *Journal of Oral and Maxillofacial Surgery*. 2005;63(11):1626-1633. doi:https://doi.org/10.1016/j.joms.2005.06.010
21. Orsini G, Traini T, Scarano A, et al. Maxillary sinus augmentation with Bio-Oss® particles: A light, scanning, and transmission electron microscopy study in man. *J Biomed Mater Res B Appl Biomater*. 2005;74B(1):448-457. doi:https://doi.org/10.1002/jbm.b.30196
22. Donovan CMG, Dickerson LNC, Hellstein MJW, Hanson MLJ. Autologous calvarial and iliac onlay bone grafts in miniature swine. *Journal of Oral and Maxillofacial Surgery*. 1993;51(8):898-903. doi:https://doi.org/10.1016/s0278-2391(10)80112-0
23. IturriagaMTM, Ruiz CC. Maxillary sinus reconstruction with calvarium bone grafts and endosseous implants. *Journal of Oral and Maxillofacial Surgery*. 2004;62(3):344-347. doi:https://doi.org/10.1016/j.joms.2003.08.013
24. Zins JE, Whitaker LA. Membranous vs endochondral bone autografts: implications for craniofacial reconstruction. *Surgical forum*. 1979;30:521-523.
25. 25.W. A B, Krupp S. Early secondary bone grafting of alveolar cleft defects. *Plastic and Reconstructive Surgery*. 1991;87(6):1152. doi:https://doi.org/10.1097/00006534-199106000-00062
26. Ozaki W, Buchman SR. Volume Maintenance of Onlay Bone Grafts in the Craniofacial Skeleton: Micro-architecture versus Embryologic Origin. *Plastic and Reconstructive Surgery*. 1998;102(2):291-299. doi:https://doi.org/10.1097/00006534-199808000-00001
27. Rosenthal AH, Buchman SR. Volume Maintenance of Inlay Bone Grafts in the Craniofacial Skeleton. *Plastic & Reconstructive Surgery*. 2003;112(3):802-811. doi:https://doi.org/10.1097/01.prs.0000069713.62687.f5
28. Branemark PI ., Svensson B, van Steenberghe D. Ten-year survival rates of fixed prostheses on four or six implants ad modum Branemark in full edentulism. *Clinical Oral Implants Research*. 1995;6(4):227-231. doi:https://doi.org/10.1034/j.1600-0501.1995.060405.x
29. Yildirim M, Spiekermann H, Biesterfeld S, Edelhoff D. Maxillary sinus augmentation using xenogenic bone substitute material Bio-Oss®
in combination with venous blood. *Clinical Oral Implants Research*. 2000;11(3):217-229. doi:https://doi.org/10.1034/j.1600-0501.2000.011003217.x
30. Yildirim M, Spiekermann H, Handt S, Edelhoff D. Maxillary sinus augmentation with the xenograft Bio-Oss and autogenous intraoral bone for qualitative improvement of the implant site: a histologic and histomorphometric clinical study in humans. *PubMed*. 2001;16(1):23-33.
31. Valentini P, Abensur D, Densari D, Grazian JN, Hammerle C. Complication rate with prosthodontic reconstructions on

ITI and IMZ dental implants. *Clinical Oral Implants Research*. 1998;9(1):59-64. doi:https://doi.org/10.1034/j.1600-0501.1998.090108.x

32. Piattelli M, Favero GA, Scarano A, Orsini G, Piattelli A. Bone reactions to anorganic bovine bone (Bio-Oss) used in sinus augmentation procedures: a histologic long-term report of 20 cases in humans. *The International Journal of Oral & Maxillofacial Implants*. 1999;14(6):835-840.
33. Branemark PI, Zarb GA, Albrektsson T, Rosen HM. Tissue-Integrated Prostheses. Osseointegration in Clinical Dentistry. *Plastic and Reconstructive Surgery*. 1986;77(3):496-497. doi:https://doi.org/10.1097/00006534-198603000-00037
34. Carini F, Baldoni M, Ciaravinio M, Francesconi M, Porcaro G. Metodica riabilitativa nei pazienti con atrofia mascellare severa. *Dental Cadmos*. 2009;77.
35. Eriksson RA, Albrektsson T. The effect of heat on bone regeneration: An experimental study in the rabbit using the bone growth chamber. *Journal of Oral and Maxillofacial Surgery*. 1984;42(11):705-711. doi:https://doi.org/10.1016/0278-2391(84)90417-8
36. Gatti C, W Haefliger, M Chiapasco. Implant-retained mandibular overdentures with immediate loading: a prospective study of ITI implants. *PubMed*. 2000;15(3):383-388.
37. Puranen J. Reorganization of Fresh and Preserved Bone Transplants: An Experimental Study in Rabbits Using Tetracycline Labelling. *Acta Orthopaedica Scandinavica*. 1966;37(sup92):3-77. doi:https://doi.org/10.3109/ort.1966.37.suppl-92.01
38. Lundgren S, Moy P, Johansson C, Nilsson H. Augmentation of the maxillary sinus floor with particulated mandible: a histologic and histomorphometric study. *The International journal of oral & maxillofacial implants*. 1996;11(6):760-766.
39. Carini F, Morcavallo PS, Riazzoli G. Piezosurgery e miniinvasività in chirurgia preimplantare avanzata. *Il Dentista Moderno*. Published online January 1, 2006:72-75.
40. Jaffin RA, Kumar A, Berman CL. Immediate loading of dental implants in the completely edentulous maxilla: a clinical report. *The International Journal of Oral & Maxillofacial Implants*. 2004;19(5):721-730.
41. Verhoeven JW, Cune MS, Terlou M, Zoon MAOW, de Putter C. The combined use of endosteal implants and iliac crest onlay grafts in the severely atrophic mandible: a longitudinal study. *International Journal of Oral and Maxillofacial Surgery*. 1997;26(5):351-357. doi:https://doi.org/10.1016/s0901-5027(97)80796-5
42. Sjöström M, Sennerby L, Nilson H, Lundgren S. Reconstruction of the Atrophic Edentulous Maxilla with Free Iliac Crest Grafts and Implants: A 3-Year Report of a Prospective Clinical Study. *Clinical Implant Dentistry and Related Research*. 2007;9(1):46-59. doi:https://doi.org/10.1111/j.1708-8208.2007.00034.x
43. Kamal D, S. Abida, P. Jammet, P. Goudot, J. Yachouh. Devenir des implants après chirurgie préimplantaire. *Revue de Stomatologie et de Chirurgie Maxillo-faciale*. 2009;110(2):86-88. doi:https://doi.org/10.1016/j.stomax.2008.12.004
44. Clayman L. Implant Reconstruction of the Bone- Grafted Maxilla: Review of the Literature and Presentation of 8 Cases. *Journal of Oral and Maxillofacial Surgery*. 2006;64(4):674-682. doi:https://doi.org/10.1016/j.joms.2005.12.026
45. Keller E. Endosseous Implant Reconstruction of Complete Maxillary Edentulism with Compromised Residual Bone: Surgical Options. *Implant Dentistry*. 1995;4(4):282-283. doi:https://doi.org/10.1097/00008505-199500440-00014
46. Chiapasco M, Zaniboni M. Innesti autologhi di apposizione e impianti endoossei per la riabilitazione dei mascellari edentuli e atrofici: revisione critica della letteratura e casistica personale. *Implantologia orale*. 2007;2:14-34.
47. Thor A, Wannfors K, Sennerby L, Rasmusson L. Reconstruction of the Severely Resorbed Maxilla with Autogenous Bone, Platelet-Rich Plasma, and Implants: 1 -Year Results of a Controlled Prospective 5-Year Study. *Clinical Implant Dentistry and Related Research*. 2005;7(4):209-220. doi:https://doi.org/10.1111/j.1708-8208.2005.tb00066.x
48. Barone A, Covani U. Maxillary Alveolar Ridge Reconstruction With Nonvascularized Autogenous Block Bone: Clinical Results. *Journal of Oral and Maxillofacial Surgery*. 2007;65(10):2039-2046. doi:https://doi.org/10.1016/j.joms.2007.05.017
49. Reinert S, König S, A Bremerich, H. Eufinger, Krimmel M. Stability of bone grafting and placement of implants in the severely atrophic maxilla. *British Journal of Oral & Maxillofacial Surgery*. 2003;41(4):249-255. doi:https://doi.org/10.1016/s0266-4356(03)00078-0