Reconstruction of the Atrophic Edentulous Maxilllas with Allograft Bone
(Fresh Frozen Bone) and Immediate Loading Implants

Celso Marques
Oral and Maxillofacial Surgeon,
Private Practice.
Rua Artur de Azevedo, 1217 – cj 44
São Paulo, Brazil
celso.marques@uol.com.br

Luiz Fernando Akaki Borges
Specialist in Prosthodontics Dentistry by Dental School of Ribeirão Preto - University of São Paulo
Master in Oral Medicine by Heliópolis Hospital – São Paulo, Brasil
Private Practice, São Paulo - Brazil

Alexandre Augusto Benetton
Oral and Maxillofacial Surgeon,
Private Practice.

Alberto Barlattani
Specialist in Stomatology, Implants at University La Sapienza, Roma.
Medical Director of University Tor Vergata Facultà of Dentistry, Roma.
Responsible Professor, Catedra of Prosthodontics in Tor Vergata University, Roma.

Samuel Porfirio Xavier
MSci, DDS, PhD
Department of Oral & Maxillofacial Surgery, University of São Paulo,
Ribeirao Preto, Brazil.

Suzie Aparecida de Lacerda
Department of Morphology, Stomatology and Physiology,
Dental School of Ribeirão Preto – USP
Specialist in Oral Pathology by Dental School of Ribeirão Preto - University of São Paulo
Master in Oral Rehabilitation by Dental School of Ribeirão Preto - University of São Paulo
Doctor in Oral Rehabilitation by Dental School of Ribeirão Preto - University of São Paulo
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Summary

Purpose: Assess the feasibility of reconstruction of the atrophic edentulous maxillas using fresh frozen bone and their subsequent rehabilitation with immediate loading implants and fixed prosthesis. Materials and Methods: Fourteen patients (average age 53.8) with severely atrophic maxilla received fresh frozen bone grafts for width reconstruction (onlay block grafts) and vertical augmentation of posterior regions (sinus augmentation) using particulate bone and platelet-rich plasma). After an average of 6 month from the first surgical procedure, the patients received 6 implants each with an immediate loading fixed prosthesis. Results: Implant survival rate was 100% in the evaluation period (6 to 42 months) and no significant complications occurred. Discussion: Histological evaluation of reconstructed atrophic maxillas using fresh frozen bone grafts showed the presence of cellular nucleus in a previously acellular tissue. This demonstrates the possibility of using the newly-formed bone, confirming the feasibility of using this alternative material for grafting. The installation of immediate loading osseointegrated implants 6 months after the graft has been shown to be highly predictable and reliable. Radiographically, a normal bone aspect was noted in the sinus areas that received bone grafts. The radiographs showed bone loss around the implants lower than 0.5 mm after 42 months. Conclusions: The jaw bone reconstruction with fresh frozen bone, and subsequent placement of immediate loading implants, and implant-supported fixed prostheses was shown to be a viable and highly reliable alternative.

Key words: fresh frozen bone, bone grafts, reconstructive preprosthetic surgery, augmentation, endosseous implants
Introduction

With the advent of osseointegrated implants, oral rehabilitation gained new possibilities and perspectives. In the beginning, implants were installed in areas with sufficient remaining bone. As time went by, several techniques were developed in order to reconstruct atrophic areas, and subsequently install implants, for vertical (maxillary sinus elevation, onlay bone graft, osteogenic distraction), or horizontal (onlay or particulate graft) augmentation. Several materials were also used: autogenic, homogenic, xenogenic bone and alloplastic materials.

The autogenic bone is considered the ideal standard and allows the comparison with other techniques. However, the great inconvenience/difficulty is the morbidity produced by another surgical site, frequently more painful than the receptor site. Hence, several researches have been developed looking for a feasible substitute, with a reasonable cost, quality and reliability similar to autogenic bone.

Conventional two-step dental implants have a high success rate. However, the time period between implant installation and final prosthesis placement causes several damages. For example, they may increase treatment time and the functional discomfort due to temporary removable tissue-supported prostheses, especially for total edentulous patients. Accordingly, research interest increased in shortening the time period between implant placement and prosthetic rehabilitation. In recent years, several studies have demonstrated a high success rate of early implant placement, with clinical application of immediate loading implants, especially for the lower jaw\(^{(1,2)}\). Recent publications also encourage early implant placement for maxilla\(^{(3,4)}\). However, patients with greatly reduced bone volume in the implant receptor site need tissue augmentation. This can be obtained through the combination of techniques for bone augmentation before the immediate loading implant placement\(^{(5)}\).
Therefore, this paper presents a proposal for atrophic maxilla reconstruction using fresh frozen allograft bone for width gains in the maxillary anterior region (onlay block) and maxillary sinus elevation (particulate). After the graft maturation period (6 months), every reconstructed maxilla received 6 strategically distributed implants that supported an immediate loading implant-supported prosthesis. Fourteen cases were evaluated with clinical and radiographic follow-up periods ranging from 6 to 44 months (average of 16.4 months).
Materials and Methods

The patients were submitted to a detailed anamnesis and the exclusion criteria were as follows:

- Non-compensated systemic pathologies, such as diabetes and immune disorders;
- Recent history of chemotherapy for head and neck;
- Psychological disorders;
- Unavailability for return visits for long-term control;
- Remaining teeth with uncontrolled periodontal problems.

The patients were submitted to the following laboratory tests: hemogram, coagulogram, glycemia test.

A computerized tomographic scan (CT) was requested to precisely measure the remaining bone (Figures 1 and 2), as well as to create a prototype of a precise 3-dimensional (3D) stereolithographic model (Figure 3). All patients presented with edentulous maxilla. The CT scans showed the presence of an atrophic ridge of the remaining bone Class VI\(^{(6)}\) that hinders the placement of the appropriate implants, in terms of size and location, for prosthetic rehabilitation.

The allogenic bone for the grafting was provided by the Skeletal Muscle Tissue Bank of Hospital das Clínicas of Curitiba for 2 cases and by the Tissue Bank of the Orthopedics and Traumatology Institute of the Hospital das Clínicas of São Paulo for 12 cases. This material was harvested, processed, stored and distributed following the current standards for organ and tissue transplantation. The patients were duly instructed and signed the patient informed consent form for the procedures. The cases described used tibial bands.
The prototypes were sterilized in a 2% glutaraldehyde solution for 10 hours before the surgery and were thoroughly washed with sterile physiological solution to be used in the aseptic chain for adaptation of the graft.

The bone graft material for the transplant was received one hour before the beginning of the surgery, in accordance with the protocol suggested by transplant regulatory bodies. These require that, as the bone graft is taken from the tissue bank, where it is stored in ultra-low temperature (lower than -80°C), it has to be transported in a special sealed thermal box, packed and surrounded with dry ice, by a professional of the tissue bank, who must deliver it checking the internal temperature of the package, that has to be below – 50°C (Figure 4).

After the surgical field was assembled, maintaining the aseptic chain, the bone blocks were first adjusted on the prototypes in order to be well adapted (7) (Figures 5 and 6).

When the adjustment step was almost completed, the patient was anesthetized and the incision was made medial to the alveolar ridge, from one tuber to the other, totally detaching the flap and exposing the receptor beds. This medial shift of the incision aims at creating better conditions for covering the graft, decreasing the tension of the suture (Figure 7).

Some accesses were made bilaterally to the maxillary sinus. The maxillary sinus received particulate bone (Figures 8a and 8b), associated to platelet-rich plasma (PRP) (Figure 9), after the lateral wall opening and the sinusal membrane detachment, following the conventional technique for augmentation of the maxillary sinus floor (Figure 10). In the anterior regions, bone blocks fixed with 2 screws each were adapted (Figures 11 and 12). The receptor cortical bone was perforated in some places with a round bur to facilitate the blood supply and subsequent irrigation of the graft block. A 4.0 nylon thread was used for the suture (Figure 13) and the patients were instructed not to wear dentures for 20 days. Mouthrinse with 0.12% chlorhexidine 3 times a day for 20 days was prescribed. After 7 days, the suture was removed and the provisional prosthesis was readapted.
The drug protocol consisted of one tablet of azitromicine 500mg for 5 days and dexametasone 4 mg every 12 hours for 3 days, in addition to analgesics depending on the intensity of the pain.

Six months after the surgical grafting procedures, CT scans were made to evaluate the results and to plan the implant placement (Figures 14a, 14b and 14c).

Before the surgery for implant placement, conventional impressions were taken for the total prosthesis, wax rims were made and the teeth were mounted. After the evaluation of the vertical dimension of occlusion and of the intermaxillary relation, multifunctional acrylic surgical templates were fabricated (Figure 15), similar to the total prostheses, to guide the implant positioning, and to transfer them to the working cast, in addition to record the maxillomandibular relation for articulator mounting.

The placement of the implants was performed under local anesthesia. The incisions were made on the alveolar ridge, the total flaps were detached, and the graft fixation screws were removed (Figure 16). The multifunctional surgical templates, stored in a glutaraldehyde solution, were thoroughly washed with 0.9% physiological solution and positioned. Six BTLock System implants (3.75 mm diameter and 13 or 15 mm length; BTLock Vicenza, Italy) were placed and strategically distributed, forming a polygon (Figure 17). The minimum insertion torque was 32 N. The implant mounters slided easily into the surgical template grooves. Vicryl type sutures were made without removing the implant mounters, which work as impression copings (Figure 18). The surgical templates were filled with addition-type silicone impression material (Monophase Stern Vantage; Sterngold Restorative Systems, Germany) and placed in position. The prefabricated mounters were then fixed to the templates with chemically curing resin (Pattern Resin-GC America Inc, Alsip, USA), using a procedure similar to the one used for the impression of implants with an open-tray impression. It is important that the mounters do not cause any occlusal interference, since a bite record with
acrylic resin is made at the end of the procedure in order to obtain a more precise adjustment (Figure 19). The whole set was removed from the mouth and sent to the laboratory for production of the immediate loading fixed prosthesis. Healing abutments were placed on the implants (Figure 20).

After the working casts were prepared using replicas corresponding to the implants installed, a cast-metal framework was produced by the prosthetic laboratory and the final acrylization of the prosthesis was made over the framework (Figure 21).

One day after the implant placement, the fixed prostheses were installed making meticulous occlusal adjustment (Figure 22). The patients were instructed to eat pasty consistency food during 4 weeks and to use 0.12% chlorhexidine 3 times per day for 20 days.

They patients were clinically evaluated after 1, 4, 8 and 12 weeks, and then every 2 months. Radiographs were taken immediately after the prosthetic rehabilitation and subsequently, every two months. These showed no inflammation or infection and a resorption of less than 0.5 mm, indicating success for all the implants (Figure 23). Peri-implant probing depths were demonstrated to be lower than 2 mm for all implants. The reestablishment and maintenance of the facial aspect and no gingival inflammation were observed (Figure 24).
Results

Fourteen patients were treated, seven males and seven females, with ages ranging from 35 and 67 years old (average age 53.8 years old). All patients presented with edentulous maxilla associated to severe bone resorption, and were submitted to maxilla reconstruction using fresh and frozen allograft bone. The anterior region received an onlay bone graft for horizontal augmentation, and bilateral maxillary sinus augmentation was done with particulate bone associated to PRP for vertical augmentation. All the cases progressed without any major problem. The only complication faced was a small graft exposure presented in one case after one week, which was corrected by resuturing the graft. After a six-month consolidation period, the onlay bone graft fixation screws were removed from the respective areas, and every patient received 6 implants. This was done in the areas approximately corresponding and bilateral to the lateral incisors, the first pre-molars and the first molars, so as to form a polygon. These implants received metalloplastic implant-supported fixed prosthesis (Branemark protocol type) over a maximum period of 24 hours. After an observation period of between 6 and 42 months (16.4 months in average), no implant was lost, the peri-implant health was clinically and radiographically satisfactory in all cases, and the prostheses were functioning normally, playing their role, without complaints from the patients. None of the prosthesis was fabricated with cantilevers (Table 1).
Discussion

There are many important factors to be considered in the rehabilitation of atrophic maxillas, as, for example:

- Characteristics of alveolar ridge resorption, i.e., resorption rate, and whether the resorption occurred in the height or width dimensions, as well as in the maxillary sinus extensions;
- Maxillomandibular relation and vertical dimension of occlusion;
- Assessment of esthetic principles;
- Phonetic aspects of rehabilitation;
- Characteristics of the antagonist jaw: total prosthesis, removable or fixed partial prosthesis;
- Systemic conditions of the patient.

Therefore, the alveolar ridge resorption rate, as well as its characteristics, will determine the importance of the bone reconstruction to be performed, i.e., whether it will be responsible for determining all esthetic and functional rehabilitation factors or whether the prosthetic rehabilitation will share this responsibility. Thus, the prosthesis type will be of utmost importance in the rehabilitation prognosis, i.e., in the case of fixed prosthesis, the alveolar ridge responsibility is higher for reestablishing facial profile, since the prosthesis has no gingival flange as in overdentures or hybrid prosthesis\(^8\).

Reverse planning is vital for the oral rehabilitation success and the predictability of results. For this reason, all patients were submitted to an analysis of the study models mounted on semi-adjustable articulators, to determine the vertical dimension of occlusion and the maxillomandibular relation. This phase is very important because it will determine the
discrepancy between the residual alveolar ridge and the ideal tooth positioning of the final prosthesis.

In this manner, we can evaluate the amount of bone graft necessary to recover the alveolar ridge contour, further allowing not only the implant placement, but also the recovery of the perioral muscle support, that is essential in the application of fixed prosthesis on implants.

Autogenous bone grafting for maxilla reconstruction and subsequent implant placement is a relatively common procedure with highly satisfying success rates in terms of implant stability, efficacy of the prosthetic rehabilitation and patient satisfaction level\(^{(9, 10, 11)}\).

The great inconvenience of this type of procedure is the obtention of the graft material. Due to its autogenous source, it requires another surgical bed, increasing the morbidity and complexity of the procedure. When the material need is small, there are some very common intraoral areas that are options: mentum, oblique line, maxillary tuber, ascending branch of the lower jaw. However, in cases needing more graft material we had to obtain extra-oral material, generally harvested from the iliac crest or skullcap, which implies procedures carried out in a hospital under general anesthesia, increasing morbidity and costs, and discouraging patients and professionals to accept or to propose the treatment.

Trying to avoid this inconvenience, the search for a substitute for autogenous bone yielded the homogenic material as an interesting alternative. After the bone tissue is harvested, it must be submitted to several safety treatments, seeking to avoid disease transmission and controlling immunogenicity, which include:

- Freeze drying (lyophilization);
- Ionizing radiation exposure;
- Ethylene oxide exposure;
Mechanical cleaning and ultra-low temperature freezing (-80ºC), to remove living cells from the tissue that will be transplanted.

The freeze drying process (lyophilization) presents the advantage of sterilizing the osseous tissue and making it easy to store. However, during these procedures there is a significant loss of structural properties\(^{(12)}\) with destruction of bone-inducing proteins\(^{(13)}\). The use of demineralized freeze dried bone (DFDB) allograft to recover atrophic areas is a relatively common procedure, but with controversial results, as some authors obtained good results\(^{(14)}\) while others not so good\(^{(15)}\).

The ionizing radiation exposure is effective to avoid the transmission of bacteria\(^{(16)}\) and to inactivate HIV in relatively low doses\(^{(17)}\). However, grafted tissue loses desirable biomechanical properties\(^{(18)}\).

Irradiation was considered responsible for the poor results obtained in a study on femoral homografts\(^{(19)}\). The use of ethylene oxide preserves bone integrity, but it is important to consider the toxic effects for the receptor\(^{(20)}\).

The osseous tissue processing involving harvesting, mechanical cleaning and ultra-low temperature freezing (-80ºC) produces the so called “Fresh Frozen Bone”. The low temperature contributes to the preservation of the bone-inducing properties of osseous tissue, and the maintenance of this biological property is very important for bone volume recovery\(^{(21)}\).

The risk of contamination with diseases like hepatitis B and C and AIDS in this type of transplantation is minimal. In addition to the tests applied to all the samples donated, the contamination rate of the donors tends to be lower than the rate observed in the population in general\(^{(22)}\).
The ultra-low temperature is thought to be able to rupture the cell membrane through the crystallization of the water in the cells, makes the tissue bacteria free. The presence of live cells in the fresh and cryopreserved bone samples was observed in the studies of Heyligers and Klein-Nulend\(^{(23)}\). Risk reduction for virus transmission and bacterial contamination with this type of transplantation still depends on effective serum tests of the donor. In Brazil, the Skeletal Muscle Tissue Banks follow the standards and procedures recommended by the Sistema Nacional de Transplantes – SNT (Transplantation National System).

The prevalence of disease transmission through Fresh Frozen Bone transplantation is low, considering the high number of procedures conducted today\(^{(24)}\). A study with 138 patients who underwent arthroplasty of the hip using this type of transplantation showed infection rates lower than 1\% and these were proved not to be due to the transplanted tissue\(^{(25)}\).

Another factor to be considered when using Fresh Frozen Bone for transplantation is the potential immune reaction, which includes transplanted tissue rejection. The ultra-low temperature cryopreservation reduces graft immunogenicity\(^{(26)}\). Therefore, there is no need to submit receptors to immunosuppression, although the meaning and the incidence of the immune response to this type of graft material are still not well established.

Some studies attempted to explain the risk factors of using bone grafts through the analysis of human leukocyte antigen (HLA) in blood samples. The comparison of pretransplant serum of 40 patients\(^{(27)}\), followed by HLA analyses of samples after 3, 6, 9, 12, 18 and 24 months, revealed that sensitization occurred in 53\% of the cases studied. No evidence was found, however, linking this sensitization as a risk factor influencing the incorporation of the bone graft. Another multicenter study\(^{(28)}\) evaluated 84 patients transplanted with fresh and frozen allograft bone. Serum samples for HLA analysis were obtained before surgery, and during a follow-up period from 1 month to 4 years after surgery.
Sensitization before transplanting was shown in an average of 39% of the cases, probably due to a positive history of blood transfusions and pregnancies. After grafting, there was an increase in the average of sensitization cases from 39% to 67%, with evidence of the potential immune sensitization. Notwithstanding, the link between this sensitization and grafting success was not conclusive.

The use of fresh and frozen human bone is based on the selection of a material that safely maintains as much as possible of the desirable properties, biological and biomechanical, for maxillomandibular bone reconstruction.

The maintenance of the biological properties (still quantitatively uncertain) basically refers to maintaining the bone-inducing potential of the bone graft. The death of the bone matrix is believed to provide osteoblast-inducing factors and other essential proteins and/or an osteoclast substrate for direct bone remodeling\(^{(29)}\).

As to the maintenance of biomechanical properties, it is important to notice that the peri-implant bone is frequently submitted to mechanical stress. Therefore, the formation of bone with good density is desirable. Cryopreservation maintains the structural characteristics of osseous tissue\(^{(30)}\), and this is an important factor for the promotion of a proper osseous conduction. Onlay block grafts lose their structural integrity when submitted to lyophilization or irradiation\(^{(12, 18, 30)}\).

The fresh frozen bone discussed in this paper has been used for a long time in orthopedics, but there is limited literature in oral and maxillofacial surgery\(^{(31)}\).

In this study, all graft surgeries were carried out with platelet rich plasma placed between the bone block and the receptor bed. This was done in the cases of onlay block graft, as well as when added to the particulate bone used for maxillary sinus augmentation, in order to accelerate new bone formation\(^{(32)}\) and to facilitate the handling of the particulate material\(^{(33)}\).
It is possible to see the ossification on the histological study. These histological sections were obtained at the time of implant placement and focus on the interface between receptor bone and graft.

The sections examined reveal bone tissue composed of mature trabeculae with osteocytes inside surrounded by medullary connective tissue, rich in blood vessels, fibers and cells with normal histological appearance.

Images 25, 26 and 27 show the interface between the implanted bone tissue (left), which is more compact and without osteocytes, and the bone formed after grafting (right). Images 28 and 29 show the bone formed after grafting in more detail.

Today, immediate or early prosthetic rehabilitation on implants for edentulous maxilllas is a predictable and reliable procedure\(^{4,34}\). In addition, the possibility of using osseointegrated implants for reconstructed maxilllas through bone grafting is well demonstrated\(^{10,11,35,36}\) and represents today a relatively common treatment alternative.

In this study, at the time of the graft reopening and placement of the implants, the bone appeared to be of excellent quality. This property provided good initial stability, with insertion torque higher than 32N, sufficient to indicate immediate loading\(^{3,37}\). A discrete bone resorption was observed, probably due to the graft being cortical.
Conclusions

Reconstruction of atrophic maxillas using Fresh Frozen Bone presented encouraging results with preservation terms of up to 42 months. In addition, immediate loading on edentulous maxillas is viable as long as there is quality bone structure in a sufficient amount to enable good distribution and primary stability of the implants. However, this is still a fruitful field for further research.
References


Table 1 - Patients treated, period in use and complications found

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Images 25, 26 and 27 show the interface between the implanted bone tissue (left), which is more compact and without osteocytes, and the bone formed after grafting (right).
Images 28 and 29 show the bone formed after grafting in more detail.
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Figure 27 – (100X)

Figure 28 – (50X)