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Reconstruction of severe atrophic jaws with Fresh Frized Bone Allografts: clinical histologic and histomorphometric evaluation

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Abstract. – OBJECTIVES: Rehabilitation of maxillary edentulism with implant-supported prostheses has come into common clinical practice. Although autologous bone has osteoinductive, osteoconductive and osteogenetic properties, its use is subject to certain disadvantages such as: Increased morbidity Limited amount of bone harvested from each donor site.

AIM: The aim of this study is to analyze clinical, histological and histomorphometric results of homologous bone for implantoprosthetic rehabilitation in severe atrophic jaws

PATIENTS AND METHODS: Twenty consecutive patients, 14 female and 6 males, were treated with homologous bone bank. Treatment protocol consist of: first surgycal step, trasversal and vertical volume restore, second surgycal step: screw remove, specimen biopsy and insert implant fixtures.

RESULTS: Data show that Fresh Frozen Bone Allografts (FFBA) could be a valuable substitute for autologous bone, in as much as histological and histomorphometric results are widely overlapping.

CONCLUSIONS: Homologous bone is a valuable option for its large availability with a low cost, good versatility, no morbidity at the donor site, shorter surgical time and hospital stay.

Key Words:

Bone substitutes, Tissue physiology, Structural biology, Surgical techniques, Guided tissue regeneration, Bone regeneration, Periodontology, Sinus floor elevation.

Introduction

Extensive resorption of the edentulous jaws may cause unfavourable vertical, transverse and sagittal interarch position making implant insertion impossible and compromising also an aesthetic and functional prosthetic rehabilitation. Several surgical procedures have been proposed in the last 30 years (e.g. onlay and inlay bone graf; maxillary sinus grafting; guided bone regeneration (GBR), sandwich osteotomy, osteodistraction, segmental Le fort I osteotomy, etc)[1-8]. Although autologous bone is considered the gold standard among the graft materials, there are some drawbacks at is use: Harvested bone from the symphysis, ramus buccal shelf, iliac crest and calvarium provide an adequate amount of grafted bone volume. However, there is some variability of the type of bone quality and quantity available for collection in these donor sites and high morbidity at the donor site[9-16].

The aim of this study is to evaluate the efficacy of Fresh Frozen Bone Allografts (FFBA) in reconstruction of severe atrophic jaw.

Patients and Methods

Twenty consecutive patients (14 females-6 males) with severe jaws resorption were selected for surgical treatment of the atrophic jaws. Preoperative evaluation consisted of a general healt analysis; analysis of the remaining dentition and interarch relationship; conventional panoramic radiograph; plaster models and photographs. Computed tomography (CT) scans reformatted with Dentascan software were requested. By means of radiographic imaging and dental cast mounted on articulator, a surgical splint was made according to the estimated intermaxillary position, the right position of the implants and the facial esthetic improvement.

We focused on three items:

- Total amount of gained bone
- Total amount of vital bone in the grafted area
- Postoperative recovery

Ridge measurements were taken at baseline, graft placement, and at 5-month reentry surgery

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with a surgical calliper. Postoperative complication were carefully analized and any complication such as infections, wound deiescences, graft exposure and graft resorption were reported. After five months bone specimen were collected from the grafted size with a 3.5 × 13 mm trephine bur under cold sterile saline solution irrigation and histologic and hystomorphometric analises were requested. At the same time titanium dental implants were inserted by means of surgical stents. Patients were also asked to subjectively evaluate postoperative recovery of the reconstructive phase in terms of pain, swallow and neurosensory disturbance.

A case example illustrations is showed in Figures 1 to 9.

Surgical Procedure

FFBA was prepared in blocks in a sterile environment by the Regional Tissue Bank of Trevi-

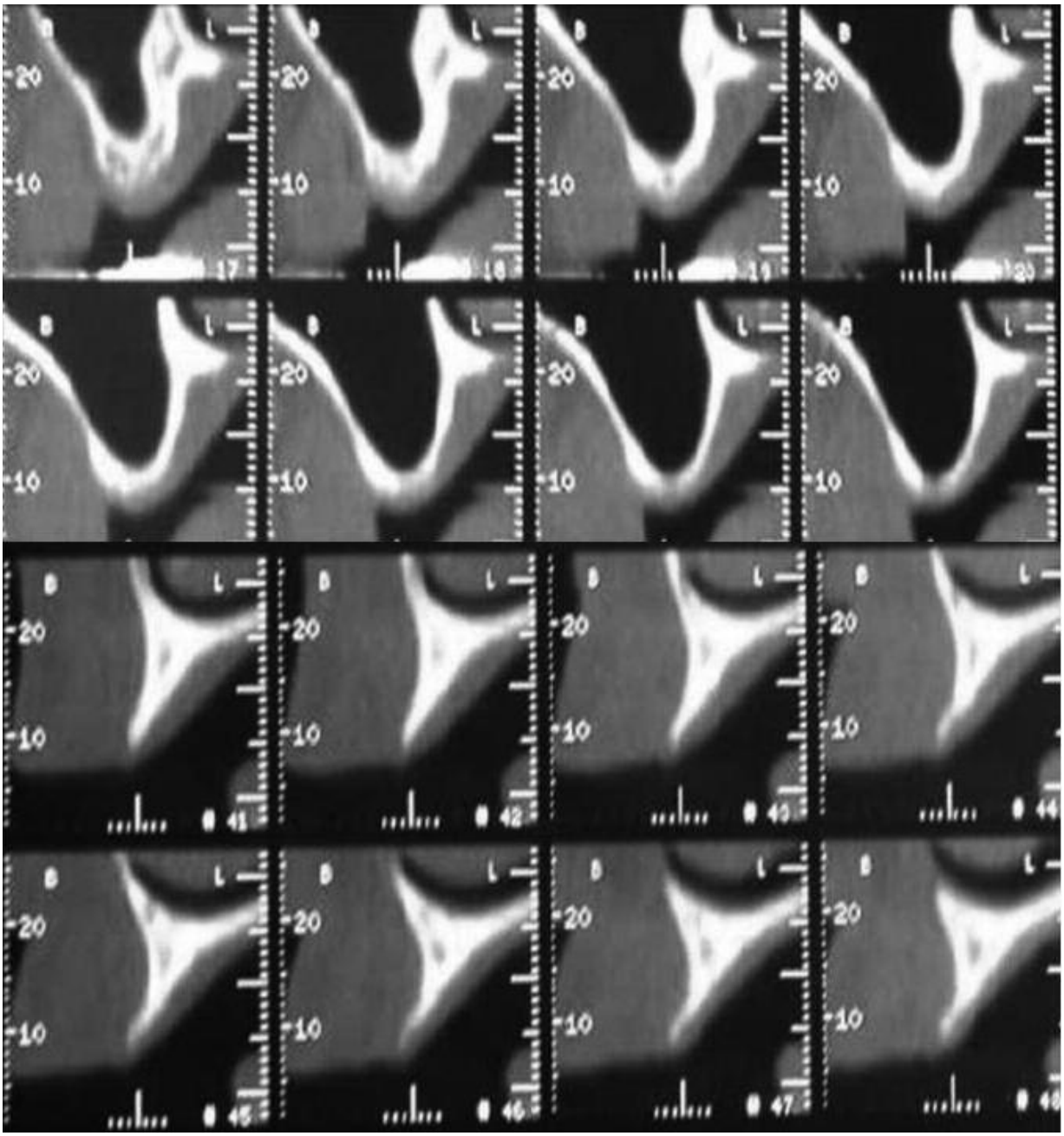

Figure 1. Preoperative view of the atrophic maxillae. TC Dentascan.

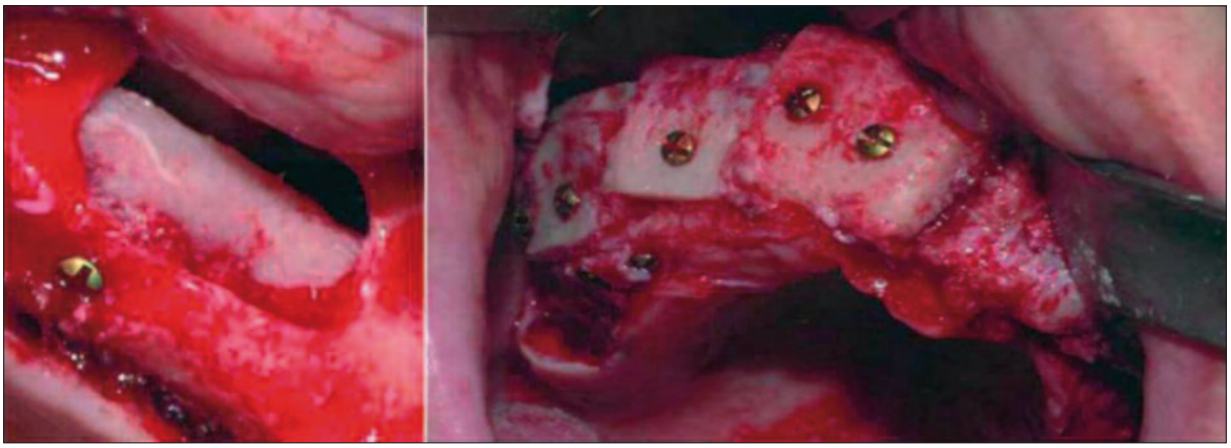

Figure 2. Sinus lift with cortico-cancellous bone graft and onlay bone grafts.

so, Italy. Molecular screening were perfomed and then the blocks were placed in a refrigerator at –80°C immerged in a solution of Vancomycin (100 µg/ml) Ceftazidime (240 µg/ml) Lincomycin (120 µg/ml). Two kinds of surgical techniques have been used to manage different types of bone defects (Table I). When maxillary sinus was interested in the osteotomy, care was taken to preserve the mucous membrane of the sinus. A cortico-cancellous bone allograft was then shaped to be inserted in maxillary sinus: the blocks were monocortical and fitted with the concellous side on the alveolar floor; the bone blocks were stabilized with long titanium screws (16-20 mm) to reach the cortical side of the grafts. The palatal-buccal defect were corrected by an on-lay graft fixed with titanium osteosynthesis screws. Sharp edge of the grafts were modelled with a round burr to avoid damage to the flap, defects around block margin were filled with bone chips. The techniques used in the posterior mandible is the interpositional bone graft using sandwich osteotomy technique, in which a cut is made in the bone (one horizontal and two

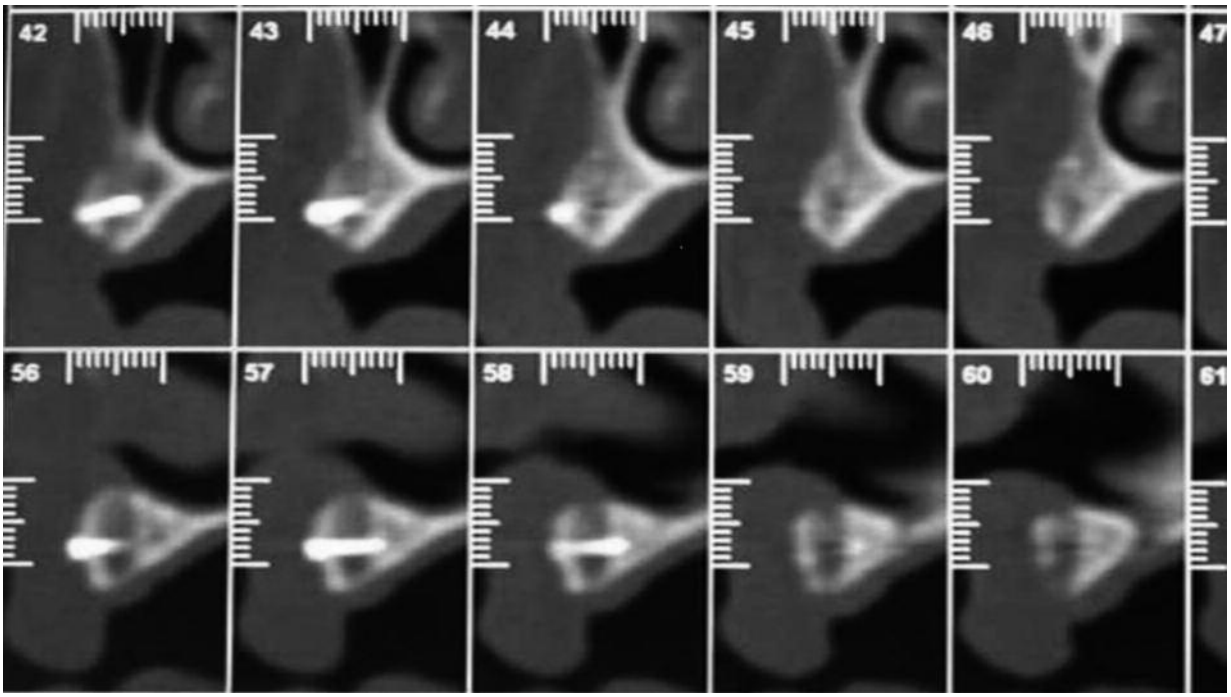

Figure 3. 5 months postoperative Tc dentascan.

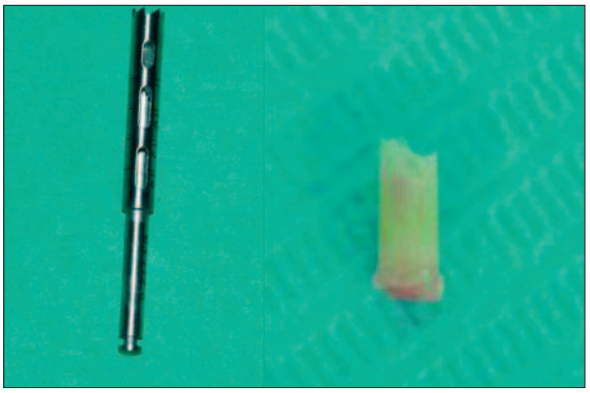

Figure 4. 3.5 × 13 mm trephine bur and bone specimen.

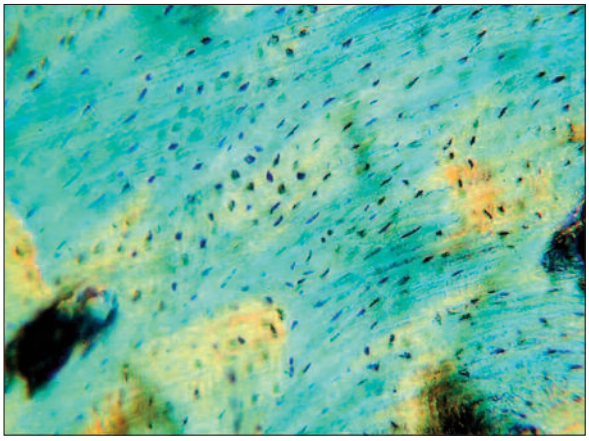

Figure 7. Lines of woven bone (D.I.C. Original magnification: 160×).

Figure 5. II phase surgery, implant surgery.

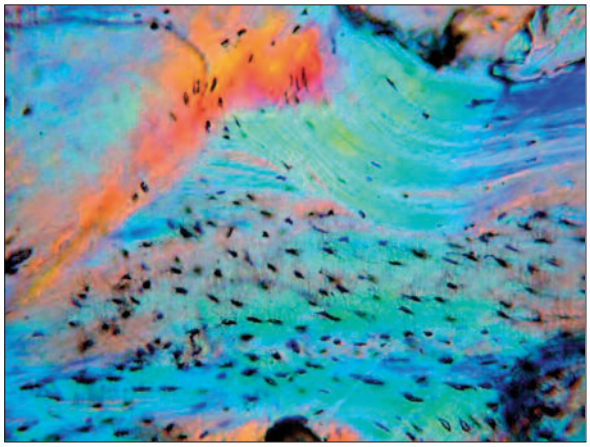

Figure 8. Vital bone containing osteoblasts, osteocytes and lines of osteoid apposition (D.I.C. Original magnification 160×).

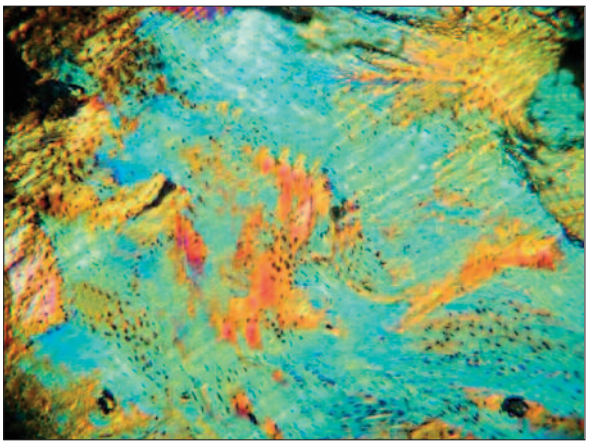

Figure 6. Histological section from homologous bone grafted material. High density of vital lamellar bone. Reduced medullary space (D.I.C. Original magnification 63×).

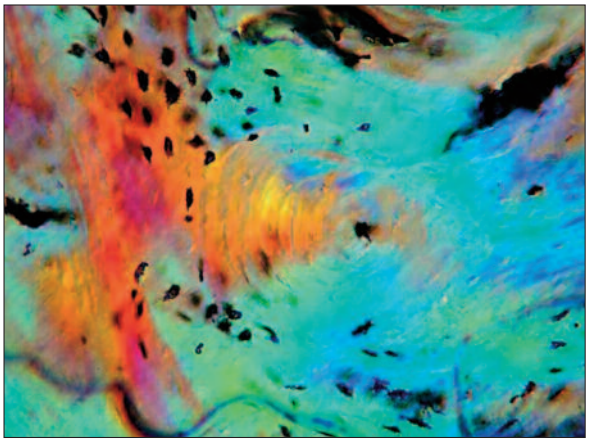

Figure 9. Vital mature lamellar bone with presence of osteon (D.I.C. Original magnification 250×).

Table I. Techniques have been used to manage different types of bone defects.

Patient	Sex	Age	Defect	Surgical treatment	Hystomorphometry	Complication	Inserted implants	Failed implants	Follow up (months)
1	F	56	Upper jaw	Le fort I+ horizontal onlay	BV 83% VB 43% NVB 40%	NO	6	0	18
2	F	39	Upper jaw	Bilateral sinus lift + horizontal onlay	BV 81% VB 43% NVB 38%	NO	8	0	13
3	F	61	Upper jaw	Bilateral horizontal onlay	BV 80% VB 44% NVB 36%	NO	6	0	9
4	M	61	Lower jaw	Mandibular vertical onlay	BV 82% VB 56% NVB 26%	NO	4	0	12
5	F	65	Upper jaw	Bilateral sinus lift + maxillary and mandibular horizontal onlay	BV 82% VB 43% NVB 40%	NO	10	1	7
6	M	57	Upper jaw	Bilateral sinus lift + horizontal onlay	BV 83% VB 62% NVB 21%	Infection and removal of the grafted bone at 2 months		0	–
7	F	46	Upper jaw	Bilateral sinus lift + horizontal onlay	BV 83% VB 57% NVB 26%	NO	4		12
8	F	62	Upper jaw	Bilateral sinus lift + horizontal onlay	BV 84% VB 66% NVB 18%	NO	8	0	7
9	F	41	Upper jaw	Right sinus lift + horizontal onlay	BV 84% VB 66% NVB 18%	NO	6	0	13
10	F	42	Upper jaw	Bilateral sinus lift + horizontal onlay	BV 83% VB 69% NVB 14%	Oro-antral comunication at 7 days, removal of the grafted bone at 1 month		0	
11	F	58	Upper jaw	Bilateral sinus lift + horizontal onlay	BV 81% VB 43% NVB 40%	NO	6	0	12
12	M	30	Upper jaw	Bilateral sinus lift + horizontal onlay	BV 85% VB 44% NVB 39%	NO	8	0	14
13	M	20	Upper jaw	Horizontal onlay	BV 85% VB 65% NVB 17%	NO	8	1	20
14	F	50	Lower jaw	Bilateral sinus lift + horizontal onlay mandibular sandwich osteotomy	BV 84% VB 66% NVB 18%	NO	8	1	7

Table continued

Table I ***(Continued).*** Techniques have been used to manage different types of bone defects.

Patient	Sex	Age	Defect	Surgical treatment	Hystomorphometry	Complication	Inserted implants	Failed implants	Follow up (months)
15	F	58	Upper jaw	Bilateral sinus lift + horizontal onlay	BV 83% VB 69% NVB 14%	Severe resorption of grafted bone at 5 months GBR + implants	8	2	134
16	F	45	Upper jaw	Right mandibular sandwich osteotomy	BV 78% VB 43% NVB 39%	NO	3	1	2
17	F	35	Upper jaw	Bilateral sinus lift + horizontal onlay	BV 81% VB 43% NVB 17%	Wound deiescence at 3 months, succesfully resolved	4	0	7
18	M	54	Upper and lower jaw	Bilateral sinus lift + horizontal onlay mandibular sandwich osteotomy	BV 82.2% VB 64% NVB 36%	NO	14	0	7
19	F	49	Upper jaw	Mandibular sandwich osteotomy	BV 83% VB 66% NVB 21%	NO	6	0	7
20	M	68	Upper jaw	Bilateral sinus lift + horizontal onlay	BV 78% VB 51% NVB 40%	NO	4	0	11

vertical) separating a mobile bone portion which is fixed (using bone plate) in its new "ideal" position. The mucoperiosteal flap was then repositioned and carefully tension-free closed with 3.0 silk sutures. Intravenous antibiotic therapy was given 1 h before the operation (2 g piperacillin and 0.25 g tazobactam) and continued intramuscularly twice a day for 5 days. Sutures were removed 10 to 12 days postoperatively, and patients were not allowed to wear prosthesis for 10-12 weeks. A soft diet was suggested. A CT scan was requested 5 months later to evaluate the gain of bone in the horizontal and vertical dimensions. Then a partial thickness flap was raised in order to place implants and remove the osteosynthesis screws; at the same time a bone specimen was collected from the grafted side with a 3.5 × 13 mm trephine bur under cold sterile saline solution.

Histologic Analyses

The sample was fixed in 4% buffered formaldehyde, then dehydrated in graded series of alcohols from 50% to 100% and embedded in Epon. Undecalcified, 30 ± 10 μm thick section along the axis of the biopsy was obtained with Isomet Buehler microtome (Buehler, Lake Bluff, IL, USA); they were stained with Toluidine blue and observed with a microscope by Normasky D.I.C. differential interference contrast (Fomi III, Carl Zeiss, Oberkochen, Germany).

Histomorphometric Analyses

A FOMI III microscope (Zeiss) connected to a computer and a Leica DC 280 digital camera (Leica Microsystem, Milan, Italy) were used for histomorphometrical measurements. Histomorphometry was performed with a softer, Alexasoft software (Microcontrol, Milan, Italy). The percentage of bone was calculated in all sections of the same sample, and the measurements were performed at 160 magnification. The vital bone (VB) was calculated as the amount of mineralized and vascularised bone tissue as a percentage of the total tissue volume (TV). The mineralized bone tissue that contained areas of empty osteo-

cyte lacunae was defined as non-vital bone (NVB) and was expressed as percentage of the TV. The total amount of vital and non-vital bone corresponded as complete bone volume (BV).

Results

Ridge measurements taken at baseline, graft placement, and a 5-month re-entry surgery demonstrated an increase in alveolar ridge width from 3 to 5 mm and in ridge height from 10 to 13 mm. In 16 of the 20 patients treated, the height and the width of the alveolar process obtained with surgery did not show any modification and implant insertion was uneventful. In one patient exposure of onlay bone grafts occurred two months after surgery. Exposed graft was removed and implant was placed, despite moderate bone resorption, in association with GBR. One patient show a little dehiscence of the wound that was successfully treated. 2 patients showed a severe resorption of bone graft due to infection of the grafted area. Bone blocks were removed and no implant were placed. A total of 121 implants were inserted. 6 implant failed prior to prosthethic phase All the patients were fully satisfied of the postoperative recovery and referred no excessive pain or facial edema. No neurosensorial injury were reported.

Histology

All the tissues were free of inflammatory cells. The medullary spaces were almost always filled with a well-vascularized connective tissue with no signs of inflammation. The examined sections revealed the presence of vital lamellar bone and some areas of woven bone surrounding NVB tissue represented by fields of empty osteocyte lacunae. The bone formation process was well identified by the presence of great amount of mature bone respect samples taken by crestal grafted bone. Moreover, the maturity of the bone was confirmed by well developed Haversian and Volkmann canal systems with the presence of osteons containing osteocytes and osteoblasts (Figures 6-9).

Histomorphometry

The histomorphometric result was: The percentage of total bone volume (BV) was 83%, Vital bone (VB) 58% and Non vital bone (NVB) was 25%. These results are encouraging if compared with those of the autogenous bone grafts (Table II)[17].

Table II. Encouraging results if compared with those of the autogenous bone grafts.

Calvarial bone grafts	BV 73.4% ± 13.1% VB 67.9% ± 16.1%. NVB 5.5%
Iliac bone grafts	BV 46.6% ± 17.4% VB 34.0% ± 21.5% NVB 12.6 ± 7.7%
FFBA	BV 83% ± 4 VB 58% ± 11 NVB 25% ± 10

Discussion

Several surgical techniques have been proposed in the past 30 years to manage jaw's atrophy. Onlay autologous bone grafts is still considered the gold standard among the grafting materials due to its osteoinductive, osteoconductive and osteogenetic properties However, these techniques are associated to relevant post-operative morbidity due to the oral or extraoral bone graft procedure (pain and/or discomfort in dehambulation, extensive haematomas of the face, damege to the mandibular nerve).

Conclusions

The use of FFBA avoids the morbidity associated with autogenous bone grafts reducing the mean hospitalisation and the patient's discomfort. Although histological results are encouraging, long term follow up is required and ongoing.

Conflict of Interest

None declared.

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