# Evaluation of the Use of Iliac Cancellous Bone and Anorganic Bovine Bone in the Reconstruction of the Atrophic Maxilla with Titanium Mesh: A Clinical and Histologic Investigation

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*The present article describes a titanium mesh procedure used for bone augmentation in the treatment of severe maxillary atrophy. A mix of iliac cancellous bone and anorganic bovine bone in a 1:1 ratio is proposed for achieving the best bone quality at the time of implant placement, which is performed 5 to 6 months after the augmentation surgery. This procedure provides for 3-stage surgery using a titanium mesh (which is removed 4 to 5 months later) to retain the cancellous bone/Bio-Oss mixture. Bone specimens taken 5 to 6 months after the augmentation procedure showed bone regeneration and the presence of vessels, indicating bone vitality.* (Int J Oral Maxillofac Implants 2001;16:427–432)

**Key words:** *anorganic bovine bone, bone graft, osseointegration, titanium mesh*

An aging world population and a progressive increase in oromaxillofacial trauma are creating new situations for the treatment of edentulous jaws and jawbone atrophy. Approximately 50% of the world population is projected to become edentulous by age 60.[1] Tooth loss is followed initially by ridge resorption, with basal bone atrophy in the years following. The typical bone resorption pattern in the maxilla provides for continuous atrophy buccally and at the occlusal face of the alveolar ridge, which then undergoes subsequent apical and palatal dislocation. The palatal vault becomes flat, and the residual ridge approaches the nasal spine anteriorly and the zygomatic process posteriorly. This anatomic situation is often associated with maxillary sinus expansion.

Severe jaw atrophy is incompatible with the realization and function of conventional complete dentures. Therefore, affected patients may require endosteal implants to retain and/or stabilize prostheses. Unfortunately, extension of the resorption to basal bone frequently makes traditional implant placement impossible because of the interference of anatomic structures, such as sinuses and alveolar nerves. Thus, implant placement may require more extensive reconstruction involving bone augmentation. Patients undergoing this kind of surgery require careful selection and consideration of their oral and general health status. Furthermore, patient psychologic motivation should be evaluated to obtain maximum compliance, considering the length and sophistication of this clinical treatment (from 6 to 18 months to the definitive prosthetic restoration).[2,3]

A surgical technique incorporating the use of titanium mesh for the augmentation of atrophic maxillae is described and demonstrated histologically.

## MATERIALS AND METHODS

### Patients

Between 1994 and 1998, 14 patients, age 25 to 61 years (mean age 43) and in good general health, were treated. Twelve patients were women and 2 patients were men; 5 subjects were completely edentulous and 9 were partially edentulous. All presented for treatment after unsuccessful use of removable prostheses, either because of denture instability or insufficient bony support for conventional implant placement. The patients were affected with type 2 bone atrophy according to the Fonseca and Davis classification,[4] ie, insufficient height and width of basal and alveolar bone was available to maintain implants.

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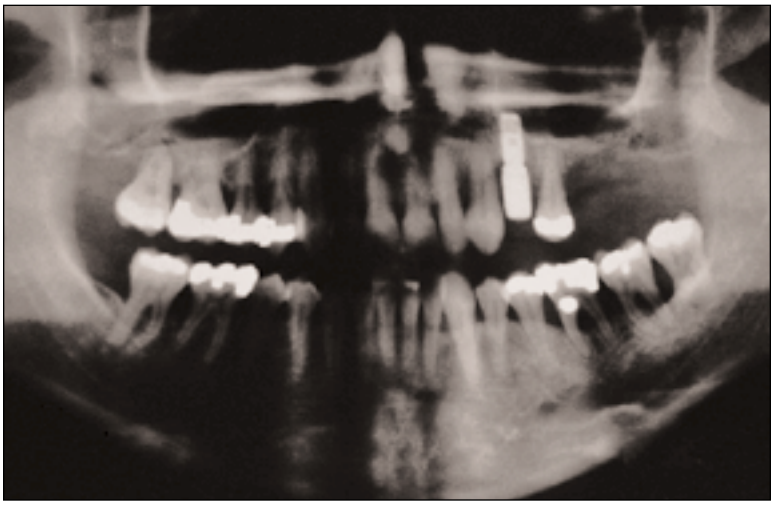
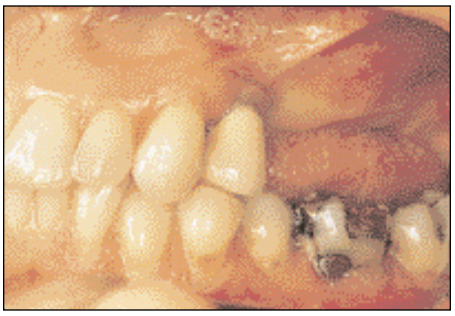


**Fig 1a** *(Left)* Panoramic radiograph showing severe atrophy with maxillary sinus expansion on the left side.

**Fig 1b** *(Below)* Intraoral view. A posterior crossbite relationship can be anticipated.



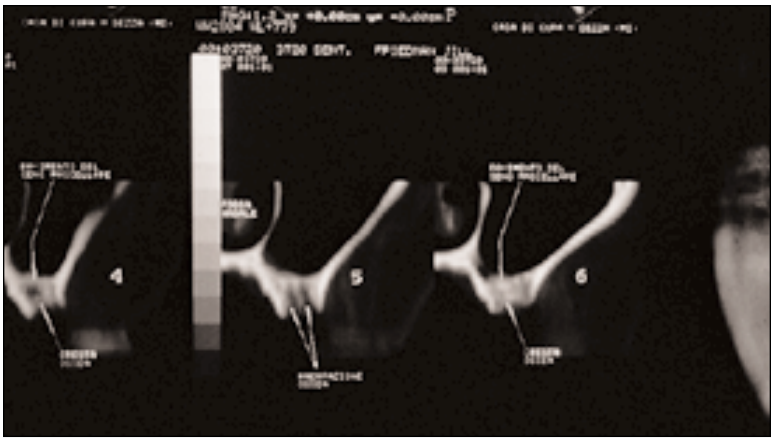



**Fig 2** Computed tomographic scans showing extreme bone resorption and sinus pneumatization, classified as type 2 bone atrophy (Fonseca and Davis classification[4]).

From an original group of 21 potential patients, 7 subjects were eliminated because of general uncontrolled disease, immune system deficiences, or severe tobacco addiction (more than 20 cigarettes/day). All patients were informed that a bone specimen would be taken from the reconstructed area at the time of implant placement (5 to 6 months after the first surgery). Preoperative radiographic investigations included a panoramic radiograph and computed tomography (CT) of the maxilla.

## Surgical Technique

The surgical reconstruction provided for both vertical and horizontal augmentation of the atrophic ridge, associated with maxillary sinus elevation when performed in the posterior areas (Figs 1 and 2). According to the technique initially proposed by Boyne and James,[5] a 0.20-mm-thick titanium mesh (Ti-Mesh, Las Vegas, NV) is used to maintain a mix of autogenous cancellous bone and anorganic bovine bone (Bio-Oss, Geistlich, Wolhusen, Switzerland)[6] above the alveolar ridge. Presurgically, a polyether impression of the edentulous area is made. Over the subsequent cast, wax is placed to simulate the desired atrophic ridge reconstruction (Fig 3a). The cast is then duplicated in acrylic resin, and the mesh is cut out over this new cast and adapted to the shape of the planned new ridge. The mesh is extended palatally to accommodate a 7- to 10-mm-long screw that secures the mesh and the graft (Fig 3b).

Prior to graft placement, the atrophic area is exposed by a mid-crestal full-thickness incision (from tuberosity to tuberosity for a complete maxillary reconstruction) (Fig 4a). The mesh is then filled with a 1:1 mixture of autogenous cancellous bone and Bio-Oss; the same material is used for the sinus elevation procedure when indicated (Figs 4b and 4c). Periosteal horizontal incisions are then made to stretch out the flap and perfectly close the soft tissues over the mesh. After this surgical procedure, the vestibule is usually compromised. For this reason, 5 months later, during surgery to remove the mesh, the buccal flap is apically sutured to the thick new periosteal surface (termed the "pseudoperiosteum"

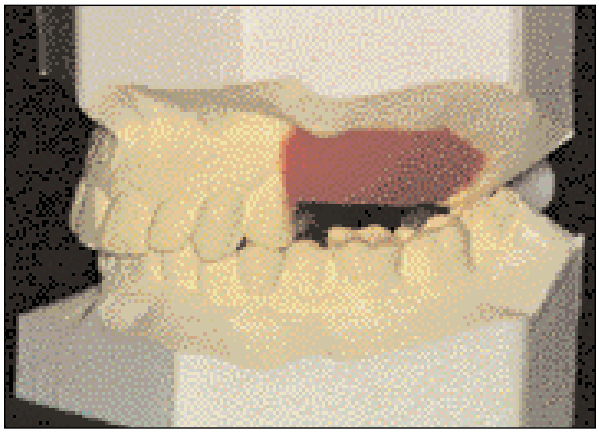


**Fig 3a** The augmentation is simulated 3-dimensionally on the cast.

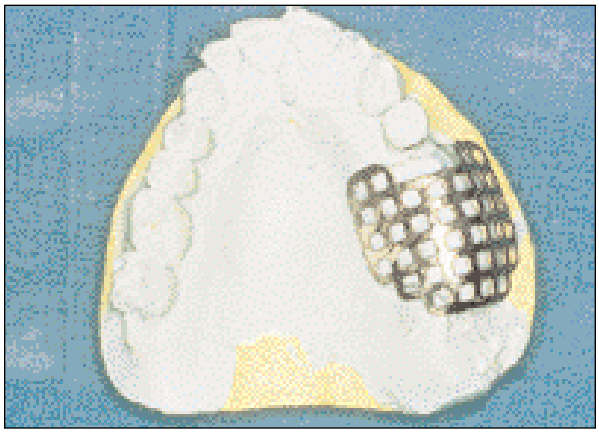


**Fig 3b** The cast is duplicated in acrylic resin and the titanium mesh is modeled.

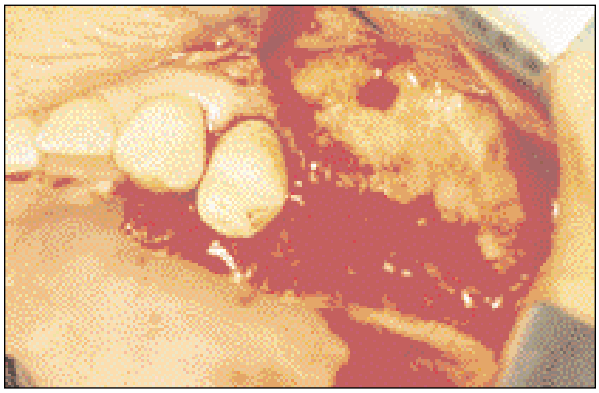


**Fig 4a** Bone exposure during initial surgery.

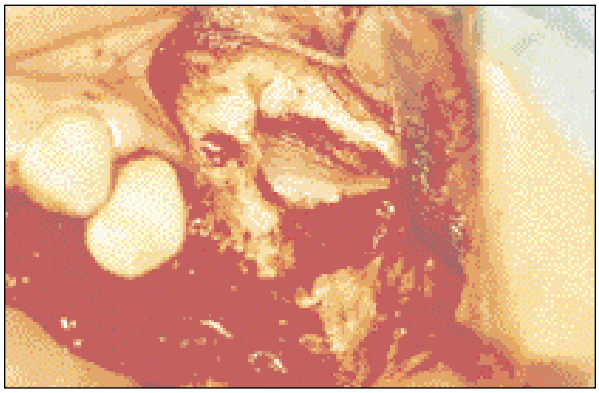


**Fig 4b** Maxillary sinus elevation.

by Boyne and James[5]) underlying the mesh to create a new vestibule by secondary epithelialization. One month after the second surgery, a new epithelial surface has formed and a third surgical procedure for the implant placement can be carried out. The 14 patients participating in this study were treated with 59 implants (Frialit-2, Friatec, Mannheim, Germany) in the grafted areas (Figs 5a and 5b).

Cancellous bone is harvested from the hip, which usually provides sufficient material for a complete maxillary reconstruction. The initial 5-cm incision is made 1 cm posterior to the anterior-superior iliac spine and 1 cm inferior to the crest of the ridge. The dissection is carried down through the fascia lata to the bone; then the medial aspect of the hip is exposed and the cancellous bone is reached by a window osteotomy. The desired amount of cancellous bone and marrow is taken and a hemostatic agent is placed in the defect prior to closure of the muscles and aponeurosis. Muscular and fascial closure is performed with 3-0 non-chromic gut sutures (Cat-gut, Ethicon, Johnson & Johnson International, Brussels,

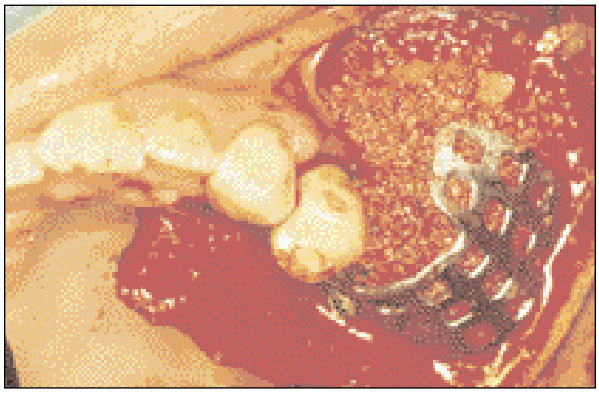


**Fig 4c** The sinus and the atrophic ridge are filled with the particulate marrow and cancellous bone/Bio-Oss mix, and the titanium mesh is placed and secured over the defect.

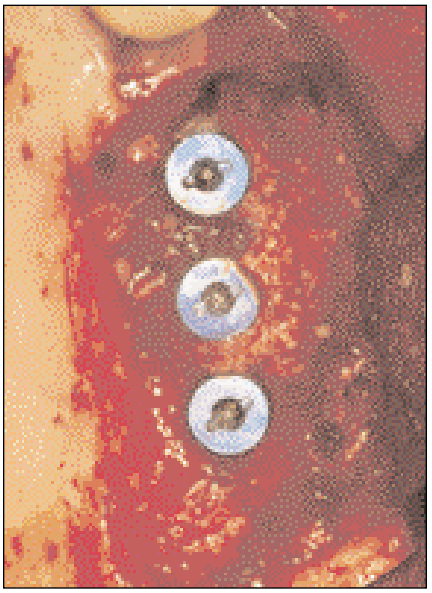
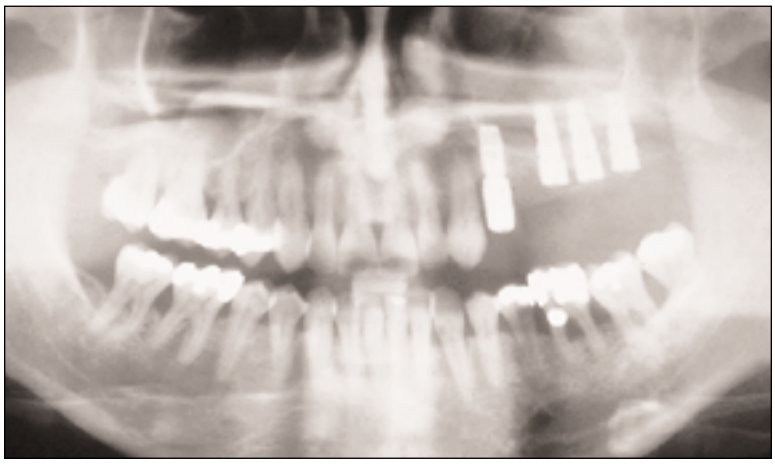


**Fig 5a** *(Left)* The implants have been placed in the reconstructed area.

**Fig 5b** *(Below)* Postoperative radiograph showing the final situation prior to prosthetic loading.



Belgium) and the skin closure with 2-0 nylon sutures (Ethilon, Ethicon, Johnson & Johnson International). Depending on defect bleeding at the time of closure, a drain may be placed up to 48 hours postoperative. The sutures are removed 5 days later.[7]

### Augmentation Materials

The aim of grafting an atrophic ridge is to obtain sufficient bone volume and ideal bone density for implant placement. It is well known that autogenous bone, particularly iliac particulate marrow and cancellous bone (PMCB), is the only material that has osteoinductive, osteoconductive, and osteoproliferative qualities. Unfortunately, grafted bone is subject to a remodeling process because of osteoblast-osteoclast activity. Among the different available materials, anorganic bovine bone (Bio-Oss)[6] is one of the materials that can achieve the above-stated goals. Removal of the organic component from xenogenic bone involves mild treatment to preserve the structure and composition of the inorganic matrix. This process produces a finely crystalline, carbonated apatite similar to natural human bone mineral. Bio-Oss is composed of very tiny crystals, with a maximum size of 100 to 400 µm. The spongiosa structure demonstrates a wide interconnective pore system. This facilitates invasion of the material by new vessels, which is followed by the migration of osteoblasts. Because of its micro-macropore architecture, Bio-Oss occupies only 25% to 30% of the defect in which it is placed, leaving 75% of the space for new bone regeneration.[6,8,9]

### Histologic Examination

Specimens were taken at the time of implant placement in the regenerating bone, 6 months after the primary surgery, using a trephine bur (2×12 mm). Each biopsy specimen from the retrieved bone cylinders was immediately fixed in a 4% formaldehyde solution, then dehydrated in ethanol, embedded in methyl methacrylate resin (MMA), cut with a diamond blade saw, and ground to 80 µm. The slides were stained with toluidine blue and basic fuchsin.

## RESULTS

### Clinical Findings

The 5-month period prior to removal of the titanium mesh was uneventful, but in 2 patients a 5×5-mm mesh exposure occurred. No treatment was carried out except for weekly examinations and chlorhexidine rinses twice a day. All patients showed uneventful recovery, and no signs of infection were detected. When implants were placed 5 to 6 months after grafting, considerable bone augmentation was noted, as well as bone hardness subsequent to the density increase. All but 1 of the 59 Frialit-2 implants placed in the grafted bone achieved osseointegration within 5 months after placement. This was assessed by means of radiographic examination and clinical evaluation of stability using the Periotest instrument (Siemens, Bensheim, Germany). No signs of bone loss, dehiscence around the implants, or infection were seen.

### Histologic Findings

Large cylinders from the specimens showed cancellous bone of considerable high density, regular structure, and good trabecular continuity (Fig 6a). The trabeculae were quite vigorous and frequently comprised remnants of the autograft, which could

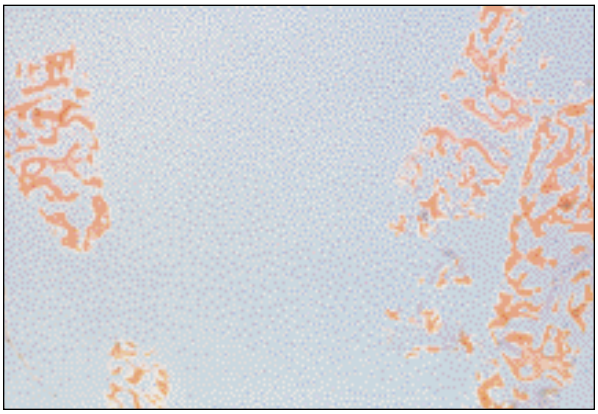


**Fig 6a** Bone cylinders from the specimens (toluidine blue and basic fuchsin; magnification ×2.5).

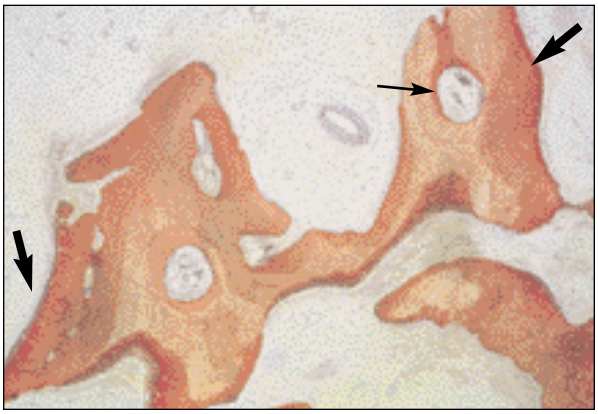


**Fig 6b** The particles of Bio-Oss are surrounded by newly formed bone *(small arrow).* The newly formed bone is recognized by darker staining *(large arrows)* (toluidine blue and basic fuchsin; magnification ×16).

be recognized by faint staining. The particles were surrounded and interconnected by new bone still undergoing remodeling and ongoing apposition of lamellar packets. Like the autografts, Bio-Oss granules could be seen fully incorporated into the bone (Figs 6b and 6c).

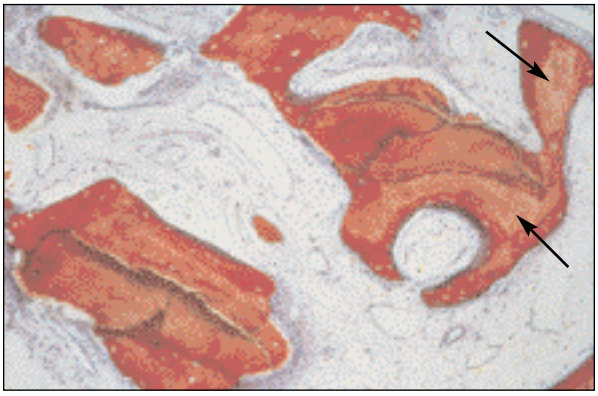


**Fig 6c** The particles of Bio-Oss are interconnected with newly formed bone; the autograft remnants can be recognized by the faint staining *(arrows)* (toluidine blue and basic fuchsin; magnification ×25).

## DISCUSSION

Current surgical procedures for the treatment of severe maxillary atrophy can provide predictable and safe results, especially in conjunction with osseointegrated implants.[10–13] Complete resorption of the autogenous bone graft, when not associated with implants, will likely result within 3 to 5 years. By simulating natural dental roots, osseointegrated implants play an osteogenic role in the grafted bone and reduce its long-term resorption.[14] In addition, a mutual stabilization function exists between grafted bone and the implant; the graft provides primary stability for the implant and the implant allows the graft to be fixed, thus reducing its resorption. According to different procedures, implant placement can be carried out at the same time as grafting surgery or 4 months later.

The present clinical and histologic study concerns one of the most reliable bone augmentation procedures in the maxilla. This procedure enables the achievement of optimal bone density and an alveolar ridge in addition to morphology repair. The original titanium mesh procedure was proposed by Boyne and James[5] in the late 1970s and had a 15-year follow-up. According to the authors, maximum bone resorption was around 20% of the original volume after 10 years. Clinical findings of the present authors' 5 years of experience using this technique can be compared to Boyne and James' results.[5] The association of Bio-Oss with PMCB permits maintenance of graft volume during cancellous bone remodeling and generally results in increased bone density. During the surgical re-entry for implant placement (5 to 6 months after grafting), resistance of the new bone to drilling was comparable to that observed for healthy natural bone. This situation encourages successful osseointegration. The only limitation of the titanium mesh procedure appears to be rather frequent mesh exposure, which leads to early graft resorption in the exposed area of about 15% to 25%.[15–18] Careful soft tissue handling and periosteal horizontal release incisions at the time of flap closure can usually circumvent this inconvenience.

Concerning Bio-Oss behavior after its grafting, approximately 2 weeks later a regenerating layer of osteoid appears over the Bio-Oss and likely represents initial immature bone. The process continues, and a new line of osteoblasts appears over the first mineral structure, leading to connection of the Bio-Oss particles. After 6 weeks, the bridging by means of new bone leads to stabilization.[6] After 1 year, almost 91% of the Bio-Oss surface has been reported to be covered by new bone.[19] The 6-month histologic examination of specimens removed at the time of implant placement in the present study clearly shows Bio-Oss particles surrounded and interconnected by newly formed bone that continues to undergo remodeling and apposition of the lamellar packets.[20–22] From the present findings, it could be assumed that the new scaffold of interconnected trabeculae, built around the included graft and Bio-Oss particles, provides good osteoconductivity. These results concur with those of other studies.[23,24]

## CONCLUSIONS

The results of this clinical and histologic study would appear to confirm that the titanium mesh bone augmentation procedure involving the use of Bio-Oss and PMCB represents a reliable technique when endosteal implants are placed, since it enhances good morphologic ridge repair and bone density increase. Of the 59 implants placed between 1994 and 1998, only 1 failure occurred, probably as a result of peri-implantitis that occurred immediately before prosthetic loading.

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