Original article

Implant placement and simultaneous localized ridge augmentation using micro titanium mesh fixed by cover screws: a clinical study in humans.

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The present study evaluates the efficacy of a mixture of deproteinized bovine bone mineral (DBBM) and autogenous bone chips graft associated with a micro titanium mesh fixed by implant cover screws, for localized ridge augmentation simultaneous to implant placement.
In 260 partially edentulous patients, 296 titanium meshes were placed and 514 implants (350 Pitt Easy and 164 3i Osseotite NT) were inserted. To evaluate the amount of bone regeneration, intrasurgical measurements were taken at first surgery and at titanium mesh removal. The healing period was uneventful in 258 surgical sites (87.2% of total meshes). In 38 surgical sites the titanium grid was exposed and 23 implants (4.45% of total implants) had to be removed at re-entry. A mean bone gain of 4.45mm (SD±2.11; range 2-11 mm) was found, which represents 94.68% filling of the defect. The results of the present study demonstrate that this technique can be used for GBR procedures in localized ridge augmentation with predictable results and without a large occurrence of complications.
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Keywords: Titanium mesh, grid, guided bone regeneration, dental implant, bone augmentation, DBBM, autologous bone.

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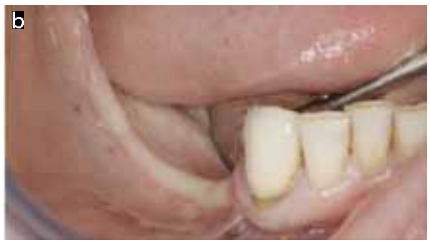
INTRODUCTION

Placement of dental titanium implants is a well-established treatment modality in edentulous areas of the jaws[1]. However, in areas with limited alveolar bone height and thickness, installation of implants may not be possible. An adequate bone volume for complete circumferential coverage of the implants is very important in obtaining long-term success of oral implants.[2] To ensure adequate bone support, many techniques are available for the treatment of bone augmentation: different surgical techniques (bone splitting osteotomy, inlay and onlay grafting, distraction osteogenesis), different materials (autogenous bone grafts, allografts, xenografts, alloplastic graft materials, bone promoting proteins and platelet rich plasma), and different barrier membranes for guided bone regeneration.[3]

Guided bone regeneration (GBR) techniques are based on the principle of compartmentalized wound healing. These techniques use special barrier membranes to protect defects from the ingrowth of soft tissue cells so that bone progenitor cells may develop bone uninhibitedly. Ingrowth of soft tissue may disturb or totally prevent osteogenesis in a defect or wound.[4-6] This

Figures 1a. Pre-panorex. Note the insufficient vertical height of the posterior mandible



Figures 1b. Pre-operative clinical image of the atrophic right side of the mandible

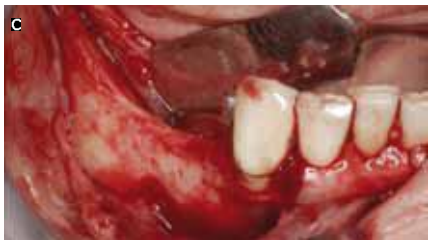


Figure 1c. Mucoperiostal elevated flap using a midcrestal incisions extending buccally and orally.

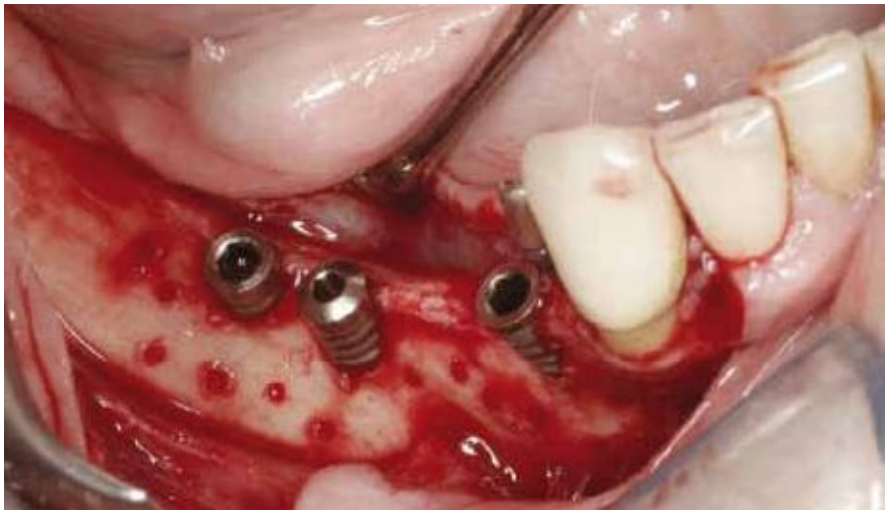


Figure 1d. The implant bed was prepared and implants were placed. Subsequently multiple perforations of the cortical bone were performed in order to expose the medullary spaces to achieve profuse marrow bleeding.

concept has been successfully utilized to treat periimplant bone defects at the time of implant placement, or to correct alveolar ridge defects before the placement of implants in animals and humans.[7-10] For the last years a number of different techniques and materials, including both resorbable and non-resorbable membranes used alone or in combination with autografts, allografts, alloplastic grafts, titanium pins, have been used in GBR procedures with encouraging results.[11-13]

In the past Boyne[14] proposed using titanium micro-mesh for restoring osseous maxillofacial defects. In recent years, titanium mesh has been used for the reconstruction of large or small osseous defects in oral and maxillofacial surgery for the purpose of implant placement.[15-20] In 1999 von Arx et al.[21] utilized the similar surgical technique (micro titanium mesh and autogenous bone grafts without membrane barrier) for the regeneration of bone in conjunction with the placement of oral implants. Some authors have used the titanium mesh to perform simultaneous GBR to the implant placement, in humans and in animals.[22-27]

The present paper reports the clinical outcome of bone augmentation of periimplant defects using a titanium mesh and a mixture of autologous bone and deproteinized bovine bone (DBBM). In this new surgical technique the micro mesh was secured to implants by cover screws, without barrier membranes.

METHODS AND MATERIALS

Subjects

From 1997 up to 2007, 260 patients (110 females and 140 males) with a mean age of 46 years (range 24-70) participated in the present study. All patients required vertical ridge augmentation to allow implant placement and to improve the crown-implant ratio. The patients were in good general health, demonstrating no systemic or local contraindications to oral surgical procedures and implant placement. They underwent oral hygiene prophylaxis and comprehensive dental care. Clinical examinations revealed compromised bone volumes at future implant sites, both for the maxillae and for the mandible. No implants were placed im-

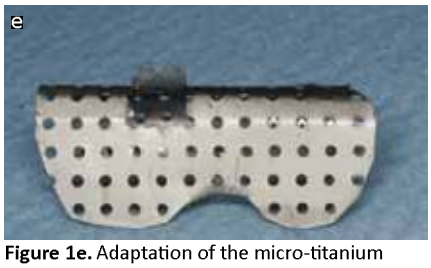


Figure 1e. Adaptation of the micro-titanium mesh to the morphology of the residual crest. A small window was created on its buccal aspect to allow for graft filling of the defect.

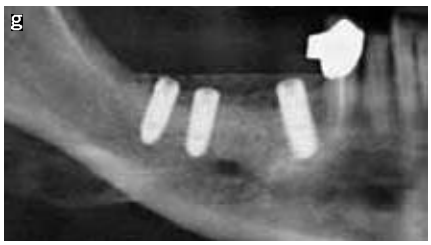


Figure 1g. Post-operative panorex following grid placement.

Figure 1h. 5 months after placement, no exposure of titanium mesh is visible.

Figure 1f. After placing the graft underneath the grid, the window of the titanium mesh was repositioned in its original position to allow suturing the flap.

mediately into extraction sockets. In some patients the titanium mesh was placed in two different fields of the maxillae and mandible. Prior to implant surgery, informed written consent was obtained from all patients.

Implants and micro-titanium mesh

Twohundredsixty (260) partially edentulous patients received a total of 296 micro titanium mesh "Bio-grid" [Cizeta Surgical S.R.L., San Lazzaro di Savena, Bologna, Italy] and 514 titanium implants (Table 1) (n=350 PITT-EASY® with a diameter of 3.25-4 mm and length of 10-16 mm [Sybron Implant Solutions GmbH, Bremen, Germany]; n=164 3i™ Osseotite NT with a diameter of 3.25-4 mm and length of 8.5-15 mm [Implant Innovations Inc., Palm Beach Gardens, FL, USA]). The type of alloy of the "Bio-grid" is titanium medical degree 2 ASTMF67 without surface treatment, the thickness is of 0.12 mm and the diameter of the holes is 1 mm and the distance between the holes is 1.5 mm.

*Clinical procedures **(Figs. 1a-l).***

The pre-operative planning consisted of clinical and radiographic examinations. Peri-apical radiographs, orthopantomographs, in some cases CT scans were used to assess the morphology of the alveolar ridge (Figs. 1a-b). Implant placement and ridge augmentation were carried out with local anesthesia, articaine 4% and epinephrine 1: 100,000 (Citocartin® 100, Molteni Dental, Milan, Italy). After a wide mid-crest incision extending buccally and orally, a mucoperiostal flap was elevated. Preferably realising incisions were avoided, but in some cases we were forced to do it and they were executed away from the grid (about 10mm) (Fig. 1c). The implant site preparation was performed according to the manufacturer's instructions; bone chips were

Table 1: Sample study

N° patients partially edentulous	N° Bio-grid and relative implants*	N° implants	Time grid removal (months)
Sites in maxillae and mandible	141 (1 implant)	350 Pitt Easy: diameter 3.25-4 mm length 10-16 mm 164 3i Osseotite NT: diameter 3.25-4 mm length 8.5-15 mm	range 4-6
	93 (2 implants)		
	61 (3 implants)		
	1 (4 implants)		
Tot. 260	Tot. 296	Tot. 514	mean 4.5

* Number of implants placed underneath each grid.

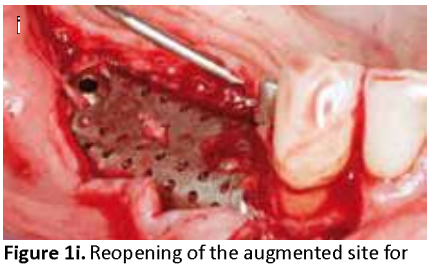


Figure 1i. Reopening of the augmented site for grid removal.

Figure 1k. The flap was repositioned and sutured with interrupted sutures, after placing healing cups.

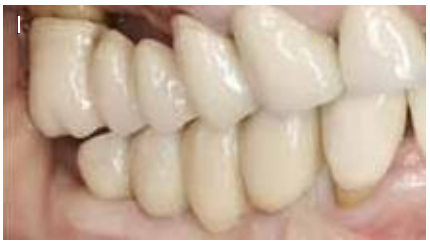


Figure 1l. Final prosthetic restoration was placed two months after second stage surgery.

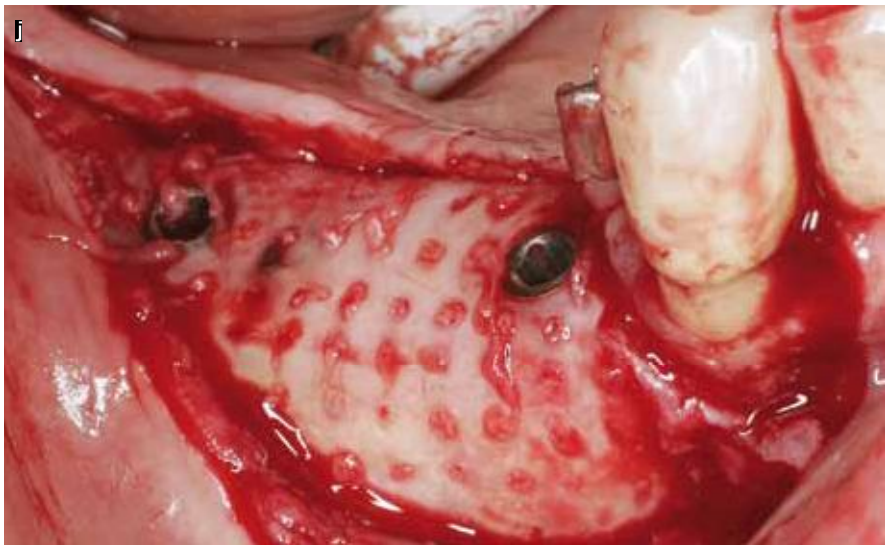


Figure 1j. The micro titanium mesh and the cover screws were removed and the regenerated tissue, clinically similar to bone, extended over the top of the implant neck.

recovered from the bone drills during implant site preparation and subsequently placed in the implant sites. The exposed implant length (A) was assessed in an apical-coronal direction, measuring the longest distance from the most coronal part of the residual crest and the implant neck, using a periodontal probe. Implants were left to protrude 0–12 mm from the top of the bone surface. Multiple perforations of the cortical bone were made in order to expose the bone marrow achieving profuse bleeding in order to activate the bone. (Fig. 1d). After adapting the micro-titanium mesh "Bio-grid" to the morphology of the residual crest, one or more holes were prepared into the grid in correspondence of the placed implants. Before placing the mesh in situ, a small window was created on its buccal surface to allow for graft filling of the defect. (Fig. 1e) Consequently the "Bio-grid" was adapted and tightly fixed over the augmented site through tightening of the implant cover screws. After grid positioning and tightening, the window was elevated and the graft was placed underneath the grid and condensed for a complete filling of the regenerating space. The grafting material consisted of a mixture of spongiosa granules 0.25-1 mm of DBBM (Bio-Oss, Geistlich, Wolhusen, Switzerland) and an autogenous bone harvested from bone drills. Thereafter, the window of the titanium mesh was repositioned in its original position to allow for suturing of the flap. (Fig. 1f). The periosteum was released to achieve a tension-free wound closure. A liquid antibiotic solution (Lincomicina cloridrate 2ml 600mg

Table 2: Bio-grids healing

	Total grids (296)*		
	Exposed	Exposed with infection	TOT
Number (%)	19 (6.4%)	19 (6.4%)	38 (12.8%)
Mean time after placement (months)	3.5 (range 2.5-4.5)		

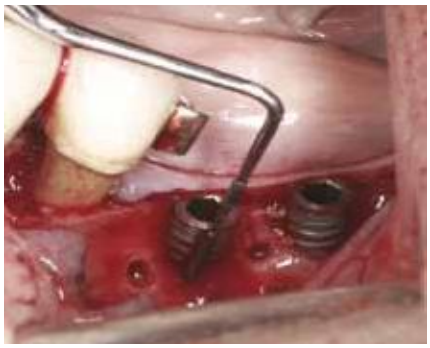
* Number tot. 296 bio-grids of the study group.

Table 3: Implants underneath exposed grids

	Implants without problems	Implants with thread exposure¤	Implants failed	TOT
Number (%)*	26 (5%)	10 (1.9%)	23 (4.5%)	59

* number tot. 514 implants of the study group

¤ These implants appeared clinically stable and were maintained for provisional and final prostheses.



Figures 2. Intraoperative measure of the defect. Implant exposure (A) was assessed in an apico-coronal direction by measuring the longest distance between the most apical part of the residual crest and the implant neck, using a periodontal probe.

Vertical initial defect	Vertical residual defect	Bone gain (mm)	Bone gain (%)
Mean A = implant exposed	**Mean B = residual defect** (remaining implant exposed)	**Mean Δ = A - B**	
4.7 mm SD±2.15 (range 0-12mm)	0.25 mm SD±0.73 (range 0-2mm)	4.45 SD±2.11 (range 2-11 mm)	94.68%

Table 4: Intrasurgical measurements to evaluate bone gain

[PHARMACIA & UPJOHN S.p.A, Milano, Italy]) was used to wash the site. Finally the flaps were repositioned and approximated with mattress and interrupted sutures.

All patients underwent antibiotic prophylactic treatment starting 1 day before surgery and then twice a day for 1 week (amoxicillin/clavulanic acid, Augmentin, GlaxoSmithKline, Brentford, UK). After surgery, an anti-inflammatory agent (Ketoprofen, Orudis, Aventis Pharma, Origgio, Varese, Italy) was prescribed to all patients for 1 week. Patients were also instructed to rinse twice a day using a 0.2% chlorhexidine solution and to refrain from mechanical plaque removal in the surgical area for 1 week. Sutures were removed 10 days after surgery and a provisional prosthesis was not used.

After a mean interval of 4.5 months (range of 4-6 months) the augmented site was reopened for grid removal. If the bone defect was greater (8-12mm) the healing time was extended to six months. The micro titanium mesh and the cover screws were identified and removed. A "pseudoperiosteum" was always found and removed, showing a highly vascularized regenerated peri-implant bone. (Fig. 1h-j) The height of the regenerated bone was assessed by measuring the residual defect (B, remaining implant exposed). For peri-implant soft tissue healing, a healing cap of appropriate length (2 to 4 mm) was inserted and the flap was repositioned and approximated with interrupted sutures (Fig. 1k). Thereafter, the patient was referred for the prosthetic treatment. (Fig. 1l)

After the final prosthetic restoration, the patients were included in a maintenance program consisting of recalls for oral hygiene and clinical evaluation every 6 months and peri-apical X-rays once a year.

Bone gain evaluation

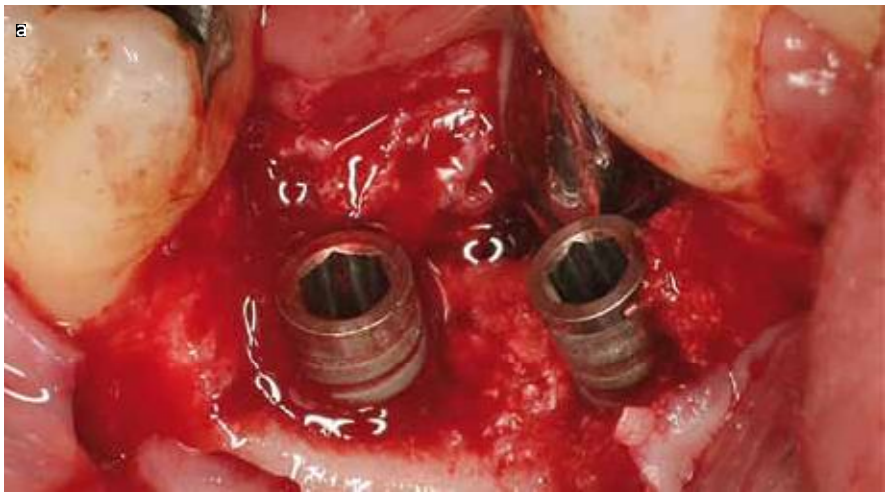
Intrasurgical measurements were taken on first surgical procedure (A = exposed implant) and at titanium mesh removal (B = residual defect) to evaluate the bone gain (Δ = A – B). The distance between the top of the implant neck and the most coronal part of the regenerated bone was measured for each implant with a periodontal probe. (Fig. 2)

RESULTS

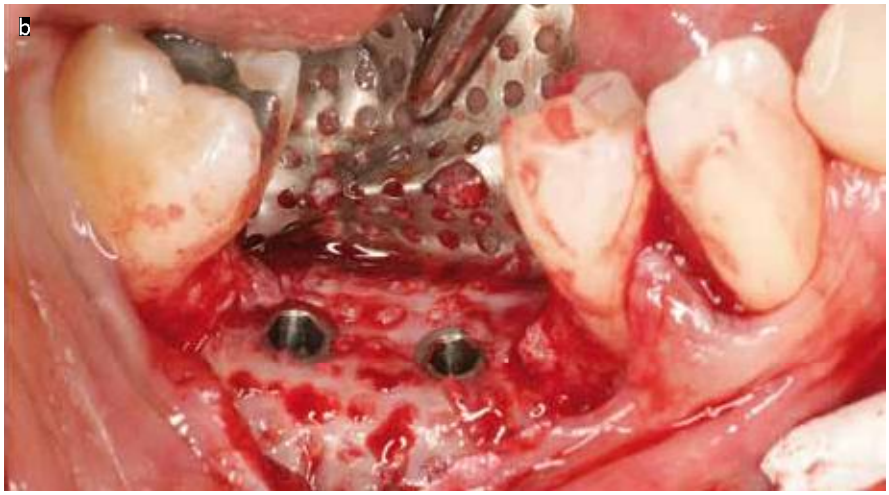
Clinical results

The healing was uneventful in 258 Bio-grid (87.2%) and 455 implants (95.55%), in which the grid was unexposed for an average 5 month period (range 4-6 months), according to the dimension of the peri-implant bone defect. In these sites, after bio-grid removal and abutment connection, a regenerated tissue – clinically similar to bone – was found and extended over the top of the implant neck and the cover-screw (Figs 1l). In most of the sites, a thin bone-like tissue layer was present between the grid's holes and above this, producing difficulty in the grid removal (Fig.3 a-b). All implants appeared clinically stable and were subsequently prosthetically loaded.

Of the 38 exposed Bio-grids (12.8%) (Table 2-3), 19 showed infection (14 within 1° month and 5 among 2° - 3° months), dehiscence and redness of the soft tissue, without swelling, pain, abscess and fistula. The 19 exposed Bio-grid remaining showed exposure without infection. In the exposed and exposed-infected grids, the site was washed using 10 ml solution of 0.2 %



Figures 3a. After implant placement in the sites 4.6 and 4.5, a vertical 4-5 mm defect was found.



Figures 3b. On surgical reentry, the regenerated tissue completely filled the initial bone defect, and a bone-like tissue was present between and above the grid's holes.

chlorhexidine and/or H_2O_2 10 vol. diluted 50%, local application of chlorhexidine gel and oral tetracycline (Bassado, Doxycycline Hyclate mg 100, Pharmacia Italia S.p.A., Milano, Italy) was administered to the patients. The time of treatment was 15-20 day, and if it improved the grid removal was delayed to 3.5 months. In the exposed grids that did not showed infection daily topical applications of chlorhexidine gel was prescribed up to the time of the re-entry (at least 4 month). The mean time before removal of the 38 exposed grids was 3.5 month (range 2.5-4.5). In a total of 38 exposed grids and 59 relative implants, 23 implants (15 Pitt Easy - 8 Osseotite) were removed at the re-entry, 10 implants (7 Pitt Easy – 3 Osseotite) showed 2 exposed threads but appeared clinically stable and were used for the provisional and definitive prosthetic rehabilitation. The remaining 26 implants (18 Pitt Easy - 8 Osseotite) were stable and did not show any thread exposure. In the site of the exposed meshes the premature mesh removal resulted in a partial loss of the regenerated bone graft and a partial bone regeneration.

In a total of 296 grids and 514 implants a mean crestal bone regeneration of 4.45 mm (SD±2.11; range 2-11 mm) was found. The mean overall bone fill of the original peri-implant defects was 94.68%. (Table 4).

DISCUSSION

The results of this study demonstrates that a mixture of autogenous bone chips and deproteinized bovine bone, associated with titanium-grid, tightly fixed by the tightening of the implant cover screws, can be used for localized vertical ridge augmentation of severely atrophic ridges.

In 258 uneventfully healed sites (87.2% of total grids) at Bio-grid removal, all implants appeared stable and submerged into a hard regenerated tissue clinically similar to bone. Only 38 surgical sites showed exposure and infection (12.8% of total grids). In a total of 514 implants, 491 (10 with 2 threads exposed) clinically stable implants were used for provisional and final prosthetic rehabilitation and only 23 implants (4.45% of total implants) failed. In the present study the mean bone was 4.45mm with mean bone gain of 94.68%. At the time of grid removal in non-exposed sites, the defect was completely restored, and the shape of the regenerated tissue matched perfectly the shape of the grid. (Figs. 3a-b) In some surgical sites the vertical bone gain was up to 10-12 mm, but it is important to underline that such defects were almost always buccal dehesions with the presence of