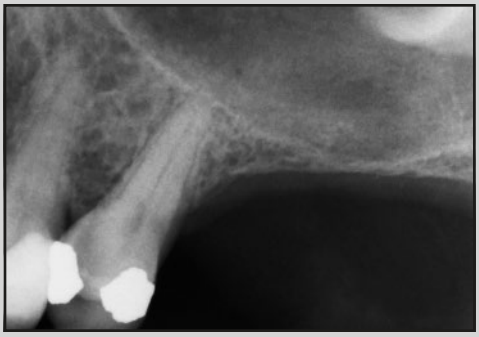
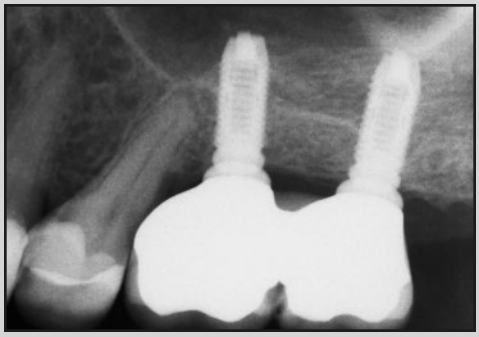
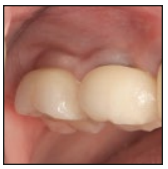




Three-Dimensional Bone Augmentation and Immediate Implant Placement via Transcrestal Sinus Lift: Five-Year Clinical Outcomes



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This study proposed a surgical technique that solves three-dimensional conditions of extreme bone atrophy. A total of 278 surgeries with transcrestal sinus lift and fresh frozen allogenous bone blocks were performed. A total of 1,024 implants were placed. After 60 months of observation, 969 implants were considered grade I (successful), 24 grade II (satisfactory survival), and 8 grade III (compromised survival). The cumulative success and survival rates, respectively, were 94.6% and 97.7%. This innovative procedure is very effective in selected cases. Fresh-frozen human bone allografts have been shown to be a reliable biomaterial to increase bone volume with simultaneous dental implant placement.
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Several studies have demonstrated high success rates for implant-supported restorations in the posterior maxilla.[1,2] In the presence of adequate bone volume, the standard surgical technique is simply preparation of the implant site. This procedure usually results in a success rate of close to 100%.[1,3] When the edentulous posterior maxilla is atrophied, the residual bone volume is not suitable for standard implant placement[4,5] and the long-term prognosis of implant-supported restorations may be poor.[6] Many surgical procedures have been proposed to augment deficient edentulous ridges and place dental implants with a one- or two-stage approach. Horizontal and vertical ridge augmentation with techniques such as split ridge expansion, vertical distraction osteogenesis, and fence technique with the use of various bone grafts have been reported with different implant survival rates.[7–11] In case of sufficient crestal bone width, a widely used modality to solve the unfavorable ridge height is based on elevation of the maxillary sinus floor by opening a bony window in the lateroposterior wall and carefully elevating the sinus membrane to a superior position.[12,13] A bone graft is then placed in the space previously occupied by the sinus to obtain a properly sized implant site.[14] The implants are inserted immediately

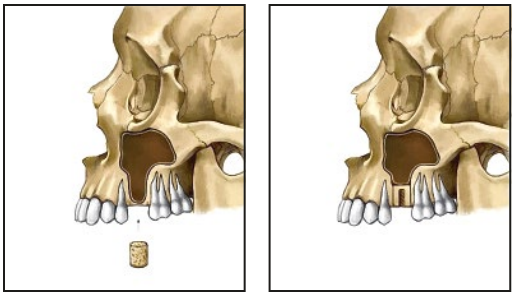

Fig 1 *The surgical procedure in case of a single implant.*

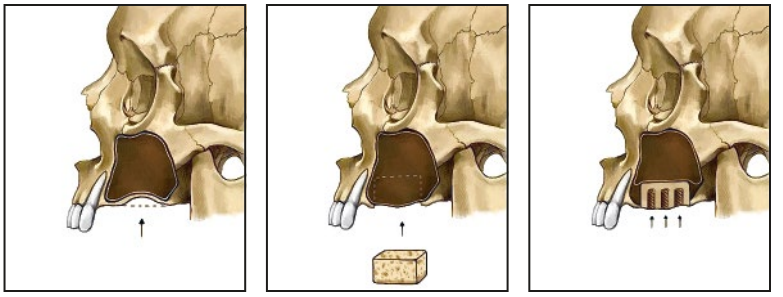

Fig 2 *The surgical procedure in case of multiple implants.*

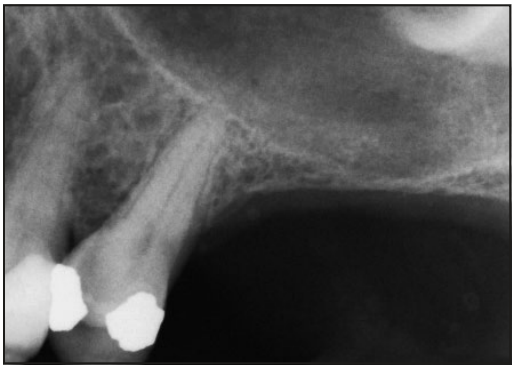

Fig 3 *Case 1: Multiple implants. Preoperative periapical radiographs.*

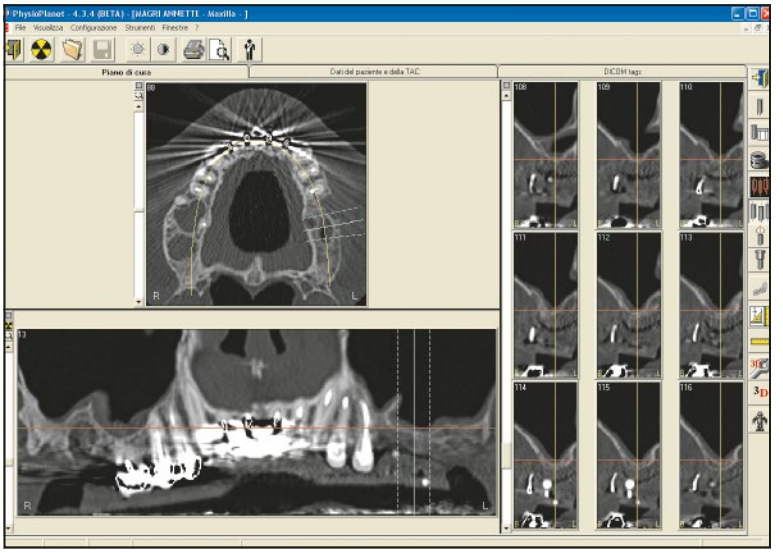

Fig 4 *Case 2: Single implants. Cone beam computed tomography.*

or after 2 to 6 months, when the area has completely healed. An alternative approach to provide implant-supported abutments in the maxillary posterior edentulous region is performed by opening a transcrestal trap door of different shape and dimensions, lifting the sinus membrane, and placing a graft material.[15–17] In this case, the implants are usually placed simultaneously.[18] Another surgical procedure that allows simultaneous ridge width increase and maxillary sinus graft consists of placing a block graft through a lateral window in the area previously occupied by the inferior third of the sinus. In this case, simultaneous implant placement is usually possible.[19–21] The present study illustrates a new reconstructive surgical technique that solves three-dimensional conditions of extreme bone atrophy (Cawood and Howell classification III to V)[22] through a single augmentative surgical procedure and simultaneous implant placement (Figs 1 and 2).

Materials and Methods

This study presents a new simultaneous surgical approach to augment the atrophic maxillary sinus region, increase the bone volume, and place dental implants. During a period of 5 years (2008 to 2013), 278 graft block augmentative procedures were performed and a total of 1,024 implants were placed. In 95 cases, bilateral sinus surgery was carried out (Figs 3 and 4).

Inclusion, Exclusion Criteria, and Preoperative Evaluation of the Patient

Inclusion criteria were patients with maxillary single or bilateral Cawood and Howell Class V to VI atrophy. Exclusion criteria consisted of the following: natural teeth adjacent

to the surgical area affected by untreated periodontal and endodontic infections, poor oral hygiene, smoking, parafunctional habits, drug or alcohol abuse, uncontrolled diabetes or other serious metabolic diseases, tumors of the jaws, chemotherapy or radiotherapy, and local ongoing or recently finished treatment with bisphosphonates. All the patients were informed regarding the study and signed a written consent form. To carry out a complete presurgical evaluation, a computed tomography (CT) scan examination, a wax-up, and a surgical template were performed for each implant site.

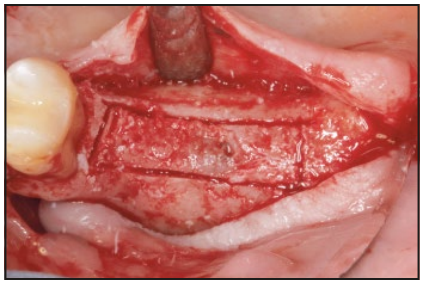

Fig 5 *Case 1: The recipient area was isolated, and the alveolar bone was completely outlined and pushed into the sinus.*

Fig 6 *Case 1: The graft was modeled by gradual reduction until exact adaptation to the recipient site was achieved.*

Surgical Technique

All patients underwent the same surgical protocol and bone augmentative procedure performed using fresh-frozen human bone allograft (FHBA) provided by the National Bank of Tissue, General Hospital of Treviso, Italy, and certified by the Italian Ministry of Health. Prior to each surgery, a slightly oversized block was removed from the sterile packaging and rinsed for 1 minute in saline solution before being placed in the recipient site.

All the subjects performed an antimicrobial prophylaxis rinsing with 0.12% chlorexidine solution for 1 minute before the surgery and three times a day for the following 10 days (Curasept 0.12%, Curaden).

Systemic antibiotic therapy was also prescribed in the form of 2 g clavulanic acid and amoxicillin for 6 days starting 1 hour before surgery (Augmentin, GlaxoSmithKline). Local anesthesia was induced by infiltration with articaine/epinephrine (Ecocain 20 mg/mL, Molteni Dental).

A full-thickness crestal incision was made with maximum effort to maintain the periodontal tissues of adjacent teeth. Vertical releasing incisions were made to obtain better visibility. The incisions were extended up to one to two teeth mesially to the surgical site and distally to the tuberosity area. A full-thickness flap was carefully reflected buccally and lingually in the apical direction to expose the alveolar ridge. Later, a buccal horizontal periosteal releasing incision was performed. This incision connected the two vertical incisions and made it possible to passively mobilize the soft tissue over the future graft site. Afterward, a trapdoor matching the dimensions of the graft was created on the edentulous alveolar ridge.

Subsequently, this isolated area was completely removed (Fig 5) by erosion, pushed into the sinus, or detached from the membrane, crushed in a bone miller, and used as additional filler during the regenerative procedure. Next, the sinus membrane was raised with extreme caution for at least 5 to 6 mm all around the trapdoor. This allowed proper placement of the graft inside the maxillary sinus without membrane tension. Following this, the graft was modeled by gradual reduction until exact adaptation to the recipient site was achieved. During this step, great attention was paid to the presence of anchorage sites in the recipient area to which the graft might be fixed.

The block was prepared with slow-speed burs under cooling until a trapezoid shape was created (Fig 6).

If the atrophy was a combined sinus and vertical atrophy, the graft was left protruding from the ridge to correct the atrophy tridimensionally. In the case of a combined horizontal and vertical atrophy, the block was modeled to simultaneously correct all the defects. Due to the plastic nature of the FHBA, the block was easily modeled, adapted, and inserted into the receiving site with some slight adjustments, usually made with a mallet and chisel. If the graft stability was not satisfactory, osteosynthesis screws were used to better settle the graft. In the case of a trapezoid graft block, all the implants were inserted after graft placement (Fig 7).

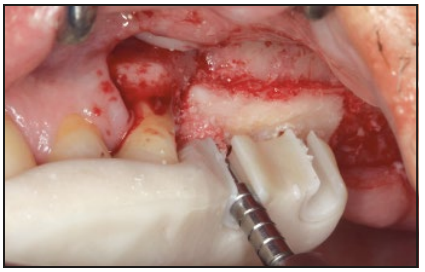

Fig 7 *Case 1: Implant site preparation.*

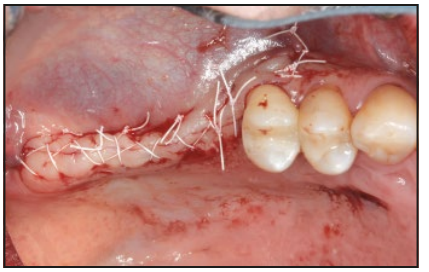

Fig 8 *Case 1: Closure of the flap with a locking continuous suture.*

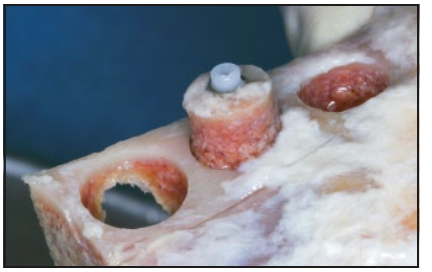

Fig 9 *Case 2: Graft preparation for single implants. The block and the recipient site were shaped using trephine drills of different diameters.*

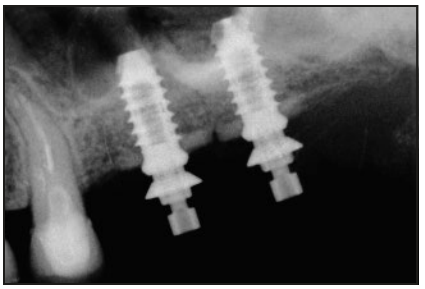

Fig 10 *Case 2: Postoperative periapical radiographs following implant placement.*

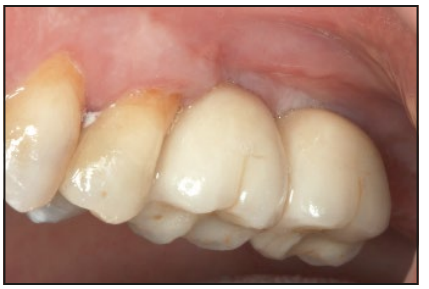

Fig 11 *Case 1: Final restorations.*

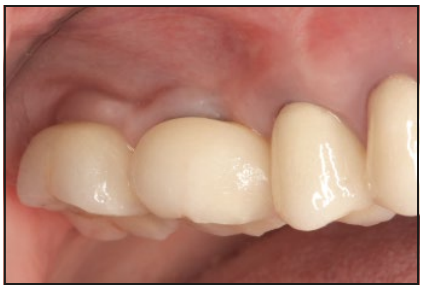

Fig 12 *Case 2: Final restorations*

In fact, the stability of the graft was usually so high that it allowed implant osteotomy and placement at the time of the graft surgery. The peri-implant graft cortical area was perforated with a no. 4 round bur. This procedure was aimed at reducing the risk of cortical graft sequestrum after the second surgery. Immediately after fixture positioning, a resorbable collagen membrane was placed to completely cover the graft. Flap closure was obtained with a locking continuous suture (Fig 8).

In the case of a single implant placement, the block was designed with a cylindrical shape. In this clinical condition, the block and the recipient site were shaped using trephine drills of different diameters (Fig 1) so that the block graft was the same diameter as the recipient site. This facilitated insertion and adaptation of the graft.

In this simplified scenario, the implant was first placed in the graft and the block was subsequently secured to the recipient site. In fact, the circular base of the bone block, once inserted, would not offer sufficient resistance to the implant insertion torque. The minimum graft width required for the use of this cylindrical block was 7 mm, because a narrower graft would have been easily fractured during implant placement (Figs 9 and 10).

Patients were instructed to have a liquid or semiliquid diet for the first 3 days and then gradually return to a normal diet. Painkillers were prescribed and used when needed (nimesulide 100 mg, Aulin, Roche). Sutures were removed 15 days after surgery.

Second-Stage Surgery

The second surgical procedure was usually performed 5 to 8 months following the graft surgery. With the help of the surgical template, the position of the implants was easily identified. In cases where a sufficient amount of keratinized tissue was present, the implant was uncovered with a small single incision that allowed proper seating of the selected healing abutments. Where keratinized mucosa was insufficient, buccal and apical displacement of the residual adherent tissue was done to increase the keratinized tissue band around the peri-implant tissues. For this purpose, a partial-thickness flap was performed. The crestal incision was oriented slightly palatally, and the entire mucogingival unit was

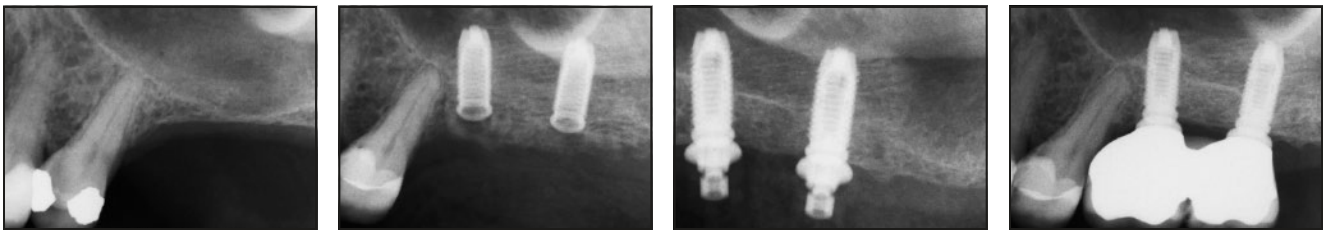

Fig 13 *Case 1: Radiographic exams at 60-month follow-up.*

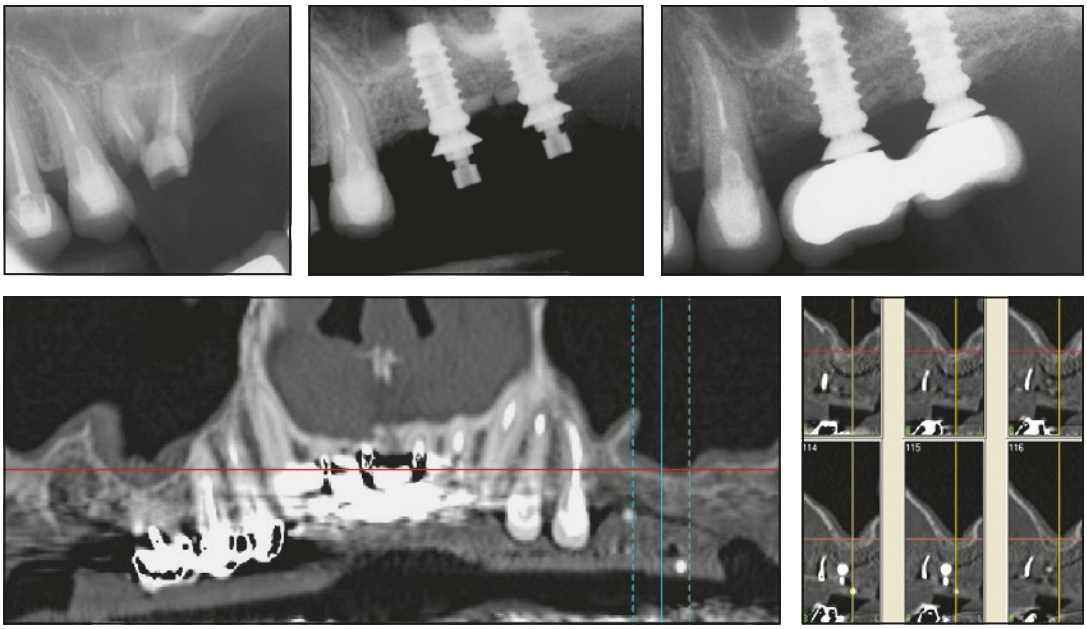

Fig 14 *Case 2: Radiographic exams at 60-month follow-up.*

repositioned apically and buccally to the implants. After complete soft tissue wound healing, a temporary restoration was placed and the peri-implant tissues were conditioned. Final restorations were delivered 3 to 4 months following implant loading (Figs 11 and 12). Clinical and radiographic evaluations were performed at baseline (T_1, final restoration delivery) and after 6 (T_2), 12 (T_3), 24 (T_4), and 60 months (T_5) following the final restoration delivery (Figs 13 and 14).

The following clinical parameters were measured:

- Implant mobility, measured by retrieving the restoration and applying a small transverse force with two opposed tool handles
- Presence/absence of signs of pain, inflammation, or infection
- Failure of the implant (specifying the reasons for failure)
- Probing depth (PD) and modified Gingival (mGI) and Plaque Index (mPI)[23]
- Cumulative survival and success rates

Implant success, survival, and failure rates were evaluated according to previously published criteria.[24] Radiographic evaluation was performed with periapical radiographs taken using a Rinn XCP ring positioner and a beam-guiding rod to allow parallelization between the x-ray tube and the film.

The final radiograph showed an apparent gap due to the presence of a radiolucent shock absorber between abutment and prosthesis.

Table 1 Implant Success and Survival Rate

	Implant success grade				
Time	I (success)	II (satisfactory survival)	III (compromised survival)	IV (absolute failure)	Available implants (n)
Baseline	1,005	0	0	19	1,024
12 mo	977	24	0	23	1,024
24 mo	969	24	8	23	1,024
48 mo	969	24	8	23	1,024
60 mo	969	24	8	23	1,024

Results

A total of 278 surgical procedures were performed and a total of 1,024 implants were placed.

At the implant uncovering performed 5 to 8 months following implant placement, 23 implants were not osseointegrated (2.25% failure rate; grade IV absolute failure).

Moreover, three graft failures caused by infection and nine cases of graft partial sequestrum were observed. All the other grafts showed a good incorporation. After 60 months, 969 implants were assessed as grade I (successful), 24 as grade II (satisfactory survival), and 8 as grade III (compromised survival) according to the ICOI Pisa Consensus Conference Score (Table 1). Consequently, the cumulative success and survival rates were 94.6% and 97.7%, respectively. The average peri-implant probing values were all normal and were not deeper than 4 mm. Although a careful plaque control regimen was followed throughout the study, slight peri-implant inflammation was detected, and positive bleeding on probing values were sometimes observed. Throughout the observation period, the mean values of peri-implant mGI and mPI scores were all within the normal range.

Discussion

This article presents a surgical procedure that allows simultaneous three-dimensional reconstruction of the atrophic maxillary ridge and implant placement. This technique eliminates the need for a second surgery to place the implants. It is based on careful preparation of the recipient site and consequent modeling and adaptation of a graft block. The use of fresh-frozen bone has been reported in orthopedic surgery, and it is considered a safe material. Among the different nonautologous graft materials, FHBA has shown low resorption, satisfactory bone volume, and high bone density for dental implant placement.[25,26] Furthermore, the presence of bone morphogenetic proteins and viable cells have been observed in fresh-frozen human bone that maintain its osteogenic potential.[27,28] A CT scan can provide clear diagnostic images of the atrophy, including the maxillary sinus, which can be helpful before and during the surgery. CT scans can also help with accurate planning of block size and shape. To carefully plan the surgery, a stereolithographic model of the receiving site may be useful. However, in most of the cases the authors recommend an easier approach that simply consists of preparing an oversized block that is then gradually reduced until it reaches perfect adaptation during the surgery. Great attention must be paid to the buccopalatal width in its most coronal area and to the presence of potential anchorage areas. For example, an increase in sinus floor bone thickness mesial or distal to the future implant site, a septum, or convergence of the palatal and vestibular walls may all be strategic areas to improve graft stability. The trapdoor, and consequently the block, will be designed with a width equal to that of the two buccal and palatal sinus walls and a length that will allow implant placement and reach anatomical areas where it is possible to fix the graft. The shape of the block will usually be trapezoidal. In the case of a sinus atrophy combined with a vertical defect, the block will be modeled to protrude and completely correct the atrophy. The vertical ridge augmentation that is obtainable using the proposed procedure cannot exceed 3 to 4 mm. To attempt a considerable vertical gain, it is necessary to perform a variation of the technique using a double layer of slow-resorbing collagen membrane and extending the healing time to 8 months. This longer healing period will usually ensure complete graft maturation. The main complications of this surgical procedure are not different from the most common complications of

other oral regenerative techniques: graft exposure or infection, wound dehiscence, and lack of graft integration. In the case of limited, partial graft exposures, it is possible to remove the exposed area, induce graft bleeding, and after careful antibiotic decontamination with rifampicin of the exposed area, completely cover the block again. This corrective procedure is often successful. Otherwise, the block has to be totally removed, the flap closed, and the augmentative surgery repeated after 2 to 3 months.

Conclusions

Within the limitations of the present 60-month clinical study, it is possible to state that the use of a bone augmentation procedure with immediate implant placement via transcrestal sinus lift is an effective technique in selected cases. FHBA grafts have shown to be a reliable alternative to autologous bone to simultaneously increase bone volume and place dental implants.

Acknowledgments

The authors reported no conflicts of interest related to this study.

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