Augmentation of the Posterior Atrophic Edentulous Maxilla with Implants Placed in the Ulna: A Prospective Single-Blind Controlled Clinical Trial

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Purpose: *To evaluate a new method to treat the posterior atrophic edentulous maxilla: dental implants placed in the ulna and transplanted with their surrounding bone blocks as inlays into the sinus. Conventional sinus augmentation with particulated autogenous bone grafts served as a control procedure.* ***Materials and Methods:*** *Fifty-two implants were placed in the ulnas of 20 patients. After 6 weeks, bone blocks containing 1 to 3 implants were harvested and transplanted into the sinuses protruding 3 to 4 mm. Implants were left to heal for 6 weeks. Twenty patients with similar treatment indications treated with particulated bone grafts from the mental symphysis, tibia, or iliac crest acted as controls. Grafts were allowed to heal for 6 months in the control group. Fifty-two control-group implants were allowed to heal for 4 months. The main outcome measures were prosthetic and implant success. Stability of individual implants was assessed with Osstell and Periotest at baseline and after 6 and 12 months of loading. Independent sample chi-square tests,* t *tests, and paired* t *tests were used with a significance level of .05.* ***Results:*** *No patient dropped out or withdrew; no prosthesis or implant failed. No major surgical complications were occurred. There were no differences between the 2 groups at any time point in implant stability. Both modalities resulted in a significant increase of implant stability at 6 and 12 months. The mean change (SD) from baseline to 1 year in Periotest measurements was 1.44 (0.48) in the test and 1.29 (0.58) in the control (paired* t *tests;* P < *.001). For the Osstell, these values were −5.88 (4.18) and −5.48 (3.93) for the test and control groups, respectively (paired* t *tests:* P < *.001).* ***Conclusions:*** *Ulna implant block grafting represents an alternative to conventional sinus augmentation, particularly when vertical augmentation is desirable or large iliac crest grafts are needed.* INT J ORAL MAXILLOFAC IMPLANTS 2007;22:280–288

Key words: *bone grafting, dental implants, sinus augmentation, ulna*

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A common clinical problem encountered in the rehabilitation of edentulous posterior maxilla is the presence of large pneumatized maxillary sinuses preventing the placement of implants. To overcome this problem, several sinus-lifting techniques have been proposed using either autogenous bone grafts (particulated or in blocks) or combinations of various types of allografts or biomaterials. An alternative technique is the use of onlay bone grafts. In some situations it may be possible to use implants placed at various angles in the pterygomaxillary region or even long zygomatic implants.[1] Although there have been a few reviews on survival rates for implants placed in grafted maxillary sinuses,[2–4] so far there is little evidence suggesting an ideal technique or graft material.[5–8] While the treatment of a single large pneumatized sinus may be usually managed by grafting bone obtained from various intraoral loca-

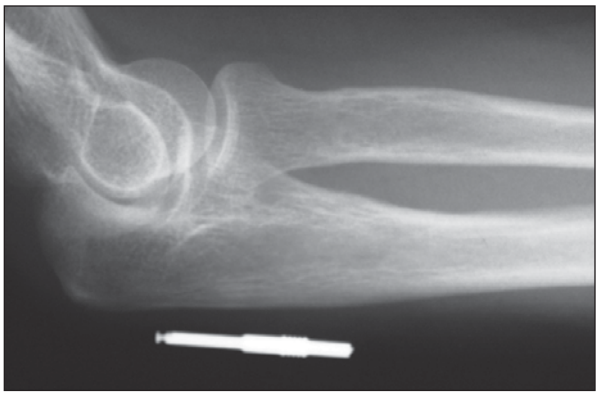


Fig 1 Lateral projection radiograph of the olecranon process of the ulna. A dental implant drill was affixed with tape to the arm for use as a reference. The radiograph provided information on the position of the coronoid process of the ulna, the portion of the ulna with the most bone available, and on the amount of available amount of bone in relation to the position of the drill.

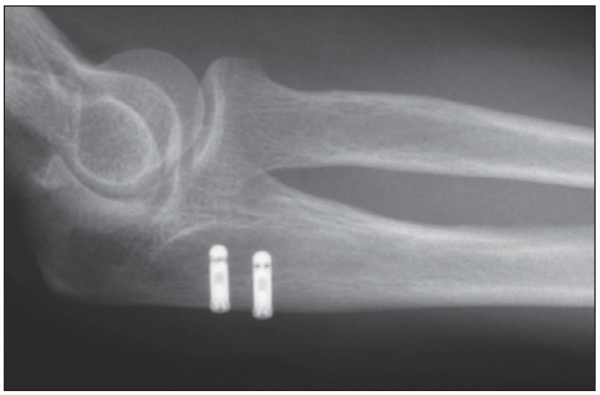


Fig 2 Lateral projection radiograph showing 2 implants placed in the ulna.

tions mixed, when necessary, with various amounts of bone substitutes, large bilateral pneumatized sinuses may require larger grafts from extraoral locations. The most commonly used extraoral donor site is the iliac crest, but other sites are used, including the tibia, the skull, and the rib. The main problems associated with extraoral donor sites are patient morbidity, which is largely underreported in the scientific literature, and scarring. It is likely that any alternative technique reducing treatment time and minimizing post-intervention suffering and scarring would be highly appreciated by the patients.

The aim of this prospective controlled clinical trial was to report the preliminary results of a new method to treat the posterior atrophic edentulous maxilla: dental implants placed in the ulna and then transplanted with their surrounding bone blocks as inlays into the sinus. Conventional sinus augmentation with particulated bone grafts from tibias, mental symphyses, or iliac crests served as a control procedure.

MATERIALS AND METHODS

Study Design

This trial was designed as a single-blinded parallel group prospective controlled clinical trial, including consecutively treated patients. Follow-up was 1 year after implant loading for all included patients. The surgical interventions were carried out in a private dental practice in Italy between January 2002 and November 2003. No ethical or institutional review board approval was sought; however, all patients signed a written informed consent. Group allocation was not random, and no matching procedures were implemented. The dental surgeon explained the various treatment alternatives to the eligible patients and suggested group allocation; however, the patients made the final decision regarding which procedure they would undergo.

Surgical procedures were performed by 2 experienced operators. A specialist in orthopedics performed all extraoral interventions, while a dentist performed the intraoral procedures. To be included, patients had to be 18 years or older and to have mono- or bilateral maxillary edentulism distal to the canine. The bone volume available at the floor of the sinus had to be 3 to 4 mm in vertical height and ≥ 6 mm in width. Bone assessments were done on computerized tomographic (CT) scans. The olecranon process of the ulna had to be large enough to harbor 1 to 3 implants at least 10 mm long; the bone was assessed on lateral projection radiographs (Fig 1). Exclusion criteria were: chronic sinusitis, recent acute sinusitis, oral lichen planus lesions, irradiation in the head and neck region or chemotherapy during the previous 18 months, severe skeletal jaw discrepancies, bruxism and clenching, and infection or bursitis of the olecranon. Other reasons for patient exclusion were: questionable willingness to cooperation; unrealistic esthetic expectations; emotional instability; psychiatric problems; substance abuse; smoking; being HIV positive; having autoimmune diseases, metabolic diseases affecting bone, uncontrolled diabetes, or serious coagulation problems; and pregnancy or lactation.

The test procedure consisted of placing dental implants in the ulna (Figs 2 and 3a). After a submerged healing phase of approximately 6 weeks, a bone block including the implant(s) was harvested and grafted as an inlay in the atrophic maxillary sinus (Figs 3b to 3f). The implant/graft was left to heal for 6

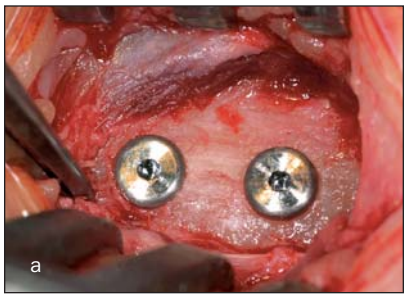


Fig 3a Two implants in the ulna approximately 6 weeks after placement.

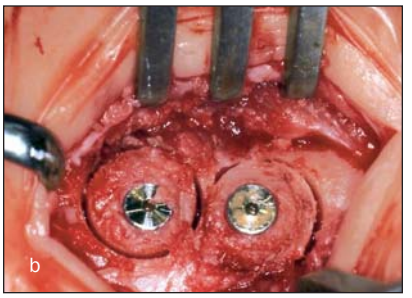


Fig 3b At re-entry after 6 weeks, a large trephine was used to retrieve the ulna-implant bone blocks.

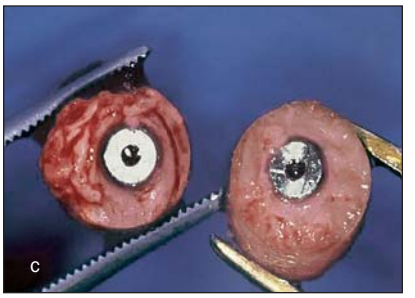
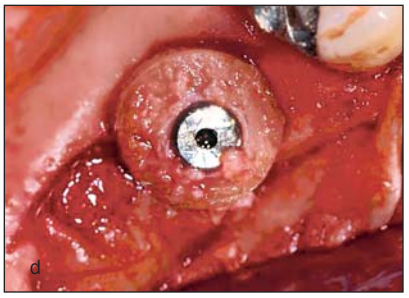


Fig 3c Ulnar bone blocks containing the implants after retrieval.



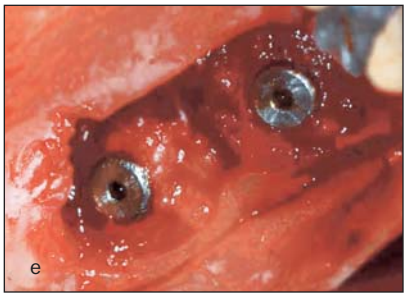


Fig 3d The first implant/bone graft was placed in the sinus using a crestal approach. No lateral window of the sinus was opened. The bone/implant blocks were not placed flush to the bone level but were left protruding about 3 to 4 mm.

Fig 3e The second implant/bone graft was placed into the sinus via a crestal approach.

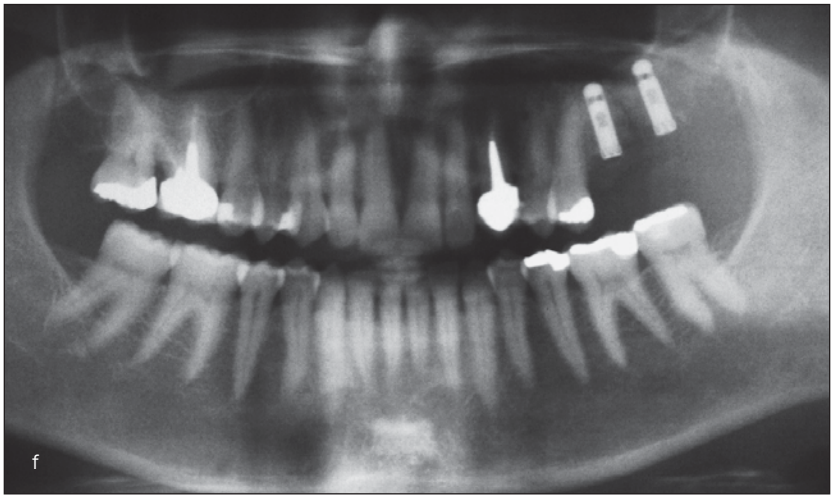


Fig 3f Panoramic radiograph showing 2 ulna bone-implant grafts in the sinus.

additional weeks before being exposed and loaded. Patients with similar characteristics acted as controls. The control procedure consisted of sinus augmentation using autogenous particulated bone graft from various intra- and extraoral locations placed between the sinus membrane and the floor of the sinus and left to heal for approximately 6 months. Implants were placed and left submerged for additional 4 months before being exposed and functionally loaded.

The following outcome measures were considered:

1. Prosthesis success. A failed prosthesis or a prosthesis that could not be placed because of implant/graft failure or implant malpositioning was considered a failure.
2. Implant success. Mobile implants, stable implants that had to be removed because of infection, or malpositioned implants that could not be restored were considered failures. Implants were

individually assessed for stability by tightening the abutment screws after removal of the prosthesis.
3. Major intraoperative and postoperative complications at donor and grafted sites.
4. Implant stability. This was measured using the Periotest (Siemens, Bensheim, Germany) and Osstell (Integration Diagnostics, Göteborg, Sweden) methods after removal of the prostheses. Periotest measurements were performed by positioning the device perpendicularly to the implant abutment on the buccal side. For each implant 4 measurements were obtained, and the value that occurred at least twice was recorded. Implants showing Periotest values between –8 and 0 were considered successful; implants with values between +1 and +5 were considered borderline, and implants with values ≥ +6 were considered failures. Resonance frequency analysis was carried out with the Osstell machine. Results were expressed as an implant stability quotient (ISQ), with values ranging from 1 (minimum stability) to 100 (maximum stability). Implants showing values ≤ 40 were considered failures. All Periotest and Osstell measurements were made by 2 independent and blinded assessors; 1 outcome assessor made all Periotest measurements, and the other recorded all ISQs.

Measurements of implant stability were performed at baseline (just before the removal of the implant/bone block from the ulna in the test group and at abutment connection for the control group), 6 months, and 1 year after loading.

The implants used were Zimmer Spline (Zimmer Dental, Carlsbad, CA) crystalline MP-1 hydroxyapatite (HA) -coated cylinders. The implant diameters used were 3.25, 3.75, and 4 mm. Implant lengths used were 10, 11.5, 13, and 15 mm.

Surgical Procedures

Test Group. A dental implant drill or a syringe needle was affixed with tape to the arm, and the reference point was marked with a pen (Fig 1). Lateral radiographs of the ulna were then obtained. The radiograph provided information on the position of the coronoid process of the ulna, which is the portion of the ulna with the most bone available, and on the amount of available bone in relation to the position of the reference mark. The reference mark on the skin was then used to guide the surgical incision.

All patients received prophylactic antibiotic therapy: 1 g ceftriaxone intramuscularly 1 day before to the intervention and 1 g once a day for 5 days postoperatively. About 10 mL of articaine with adrenalin was administered in the olecranon bursa of the ulna to achieve local anesthesia. An orthopedic surgeon made a longitudinal full-thickness incision 2.5 to 3 cm long following the olecranon process midline 2 cm distal to the apex of the olecranon. One to 3 dental implants were inserted in each ulna by the dental surgeon following the manufacturer's instructions. Ceftriaxone was applied in powder form, and the flaps were sutured. Patients were prescribed analgesics and were instructed not to lift weights, hit, pull with excessive strength, or exercise with the treated arm.

The transplantation operation was performed after approximately 6 weeks. To decrease the time the graft was outside the body, the sinus site was prepared first. A full-thickness flap was elevated, and a lateral window was opened into the sinus. Care was taken to avoid perforation of the sinus membrane. In the last 4 patients a more conservative approach was used. The sinus was approached crestally, without opening a lateral window. The bone was removed with a trephine, and the sinus membrane was gently lifted (Figs 3d to 3f). Ulnar implants were uncovered and temporary abutments were placed for the measurement of implant stability. Implants and surrounding bone blocks were harvested using 2 different procedures. In 12 patients individual implants with their surrounding bone, ie, blocks 10 or 12 mm in diameter, were removed using trephines (Figs 3b and 3c). In 8 patients bone blocks containing 2 or 3 implants were harvested (Figs 4a to 4c and 5a to 5b). When necessary, particulated bone was recovered using chisels or rongeur forceps. Ceftriaxone powder and 1 or more collagen sponges (Spongostan; Ferrosan, Soeborg, Denmark) were then placed in the donor site. In 10 patients (18 implants) the implants/grafts were placed in the alveoli just after the removal of severely compromised teeth. The extraction sites were thoroughly cleaned, and 8- or 10-mm-wide osteotomes were used to perforate and enlarge the postextractive alveoli into the maxillary sinuses to allow the placement of 10- or 12-mm-wide bone grafts. The sinus membrane was lifted, and particulated bone obtained from the ulna, mixed with about 20% demineralized bone matrix (DBM) putty (DynaGraft I, GenSci Corporation, Toronto, Canada), was packed under the membrane on the posterior sinus wall. The implant/graft blocks were then tapped in the enlarged alveoli under visual supervision. The bone/implant blocks were not placed flush to the bone level, but were left protruding about 3 to 4 mm (Fig 3d), according to the desired length, to vertically augment the crest level when needed. The same mixture of particulated autogenous bone and DBM putty was placed around the graft to completely fill the sinus window. A resorbable collagen barrier (Biomend Extend, Sulzer Dental, Carlsbad, CA) was then placed on the lateral sinus window.

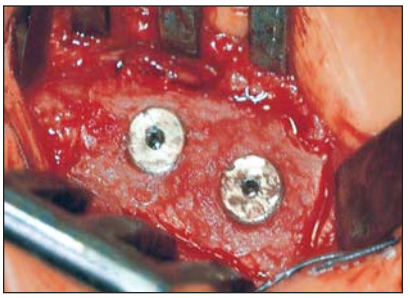


Fig 4a Preparation for the removal of a single ulna-implant block graft containing 2 implants.

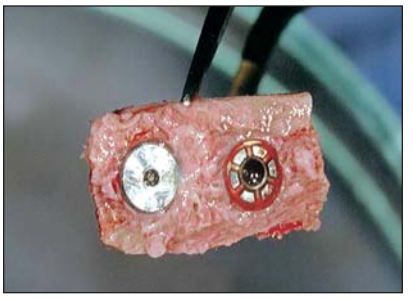


Fig 4b The single ulna block graft containing 2 implants was harvested.

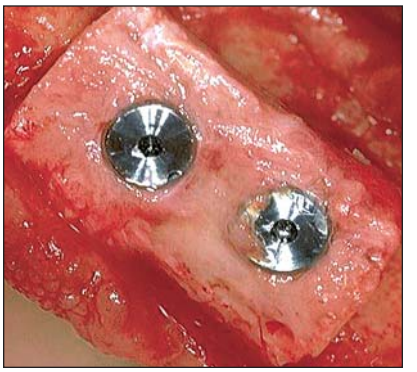
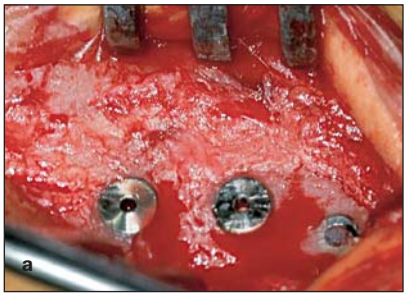


Fig 4c The single ulna block graft containing 2 implants was placed into the sinus using a crestal approach.



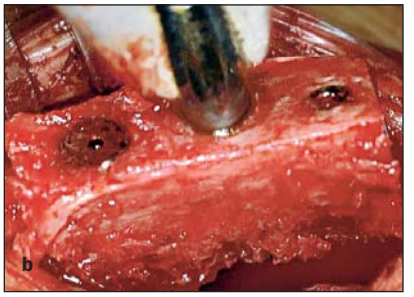


Fig 5a A case where 3 implants were placed in the ulna.

Fig 5b A single ulna bone graft containing 3 implants was harvested.

Excellent primary stability of the grafts was always achieved because of the friction between the larger implant/graft blocks and the smaller recipient sites. In areas that had been edentulous for a longer period, the sites for the implant/graft blocks were prepared with burs of increasing diameters. The diameters of the final drills were about 2 mm smaller than the diameters of the blocks. The same procedure was implemented larger block grafts containing 2 or 3 implants that were placed in prepared recipient sites (Fig 4c). No partial removable prostheses were used in the test group. After about 6 weeks abutments were placed on the implants.

Control Group. After the sinus had been opened, the necessary bone was harvested. The sinus membrane was lifted to allow the placement of 13-mm-long implants. The autogenous particulated bone graft was placed between the sinus floor and the sinus membrane. A resorbable collagen barrier (Biomend; Zimmer Dental) was used to seal the sinus window. Patients were given ice packs, prescribed analgesics, and instructed to avoid blowing the nose and using drinking straws. In case of sneezing, they were instructed to try to keep the mouth open to decrease intrasinus pressure.

Bone grafts were harvested from different intra- or extraoral locations. Iliac crest grafts were obtained for those patients in need of bilateral sinus lifts. The choice between the use of the mental symphysis or the tibia as a donor site was left to the patients, who were informed of the potential advantages and disadvantages of both the techniques.

For extraoral locations, the same antibiotic regimen administered for the ulna was used. After local injection of 10 mL of articaine, an incision in the tibia was made laterally to the insertion of the sartorius tendon and mesially to the tibia tuberosity, where the patellar ligament is inserted. The periosteum was left in situ, and a bone opening was created by cutting away a block of cortical bone. The desired amount of spongious bone was then removed with a surgical curette. The bony defect was packed with couple of collagen sponges, ceftriaxone powder was locally administered, the removed cortical bone block was repositioned in its original location, and flaps were sutured. Patients were prescribed analgesics and were instructed not to lift weights, hit, pull with excessive strength, or exercise with the treated leg.

The grafts from the anterior portion of the iliac crest were harvested under general anesthesia. Great caution was exercised to avoid the anterior cutaneous branches of the femoral nerve. The desired amount of bone was harvested using curved osteotomes.

For chin grafts, a full-thickness flap was elevated, both mental nerves were isolated, and a rectangular-shaped bone graft was harvested. The donor site was then filled with DBM putty and covered with a collagen barrier. The bone blocks were particulated with a bone mill.

Sinus grafts were left to consolidate for about 6 months before placing the implants. Implants were placed according the manufacturer's guidelines with the aid of surgical templates. Control-group implants were left submerged for additional 4 months before being exposed. Removable partial prostheses were used in the control sites.

The abutment connection procedures were done according to the implant manufacturer's instructions. When sufficient keratinized mucosa was present (12 patients in the test group and 13 patients in the control group), flapless surgery was performed. In the remaining patients a flap was elevated.

One hour prior to any intraoral surgical intervention 2 g of amoxicillin with clavulanic acid (Augmentin; GlaxoSmithKline, London, UK) was administered to each patient. Patients continued to receive 1 g 3 times a day for 5 days for all the surgical interventions with the exception of the abutment connection procedures, for which no antibiotics were given. After any surgical intervention, with exception of abutment connection, patients were seen every 4 days for the first 20 days, then every 2 weeks for 2 months, and thereafter once a month for the duration of the study. Patients were instructed to use 0.2% chlorhexidine (Corsodyl; GlaxoSmithKline) mouthwash starting 1 hour prior to any intraoral surgical intervention 3 times a day for 2 weeks and to avoid brushing and trauma on the surgical site after surgical interventions. Sutures were removed after about 1 week. Chlorhexidine mouthwashes (0.2%, 3 times a day) were also prescribed 1 week a month for the entire duration of the study. Patients were recalled for oral hygiene maintenance monthly.

Impressions were made and, after approximately 10 days, resin nonoccluding screw-retained metal-reinforced provisional restorations were delivered. The provisional restorations were progressively loaded according to the following schedule: after 15 days, the restoration was adjusted to have slight contacts in occlusion. After an additional 15 days, the prosthesis was modified to have full contacts in occlusion. Definitive prostheses were inserted approximately 45 days after abutment connection (range, 34 to 52 days) in the test group and after 43 days (range, 32 to 54 days) in the control group.

Statistical Analyses

Independent sample chi-square tests were used to compare the relative numbers of patients who had at least 1 prosthesis failure, 1 implant failure, or complications. Independent sample *t* tests were used to compare the mean Periotest and Osstell values at baseline, 6 months, and 1 year. Paired *t* tests were conducted to compare changes between baseline and 6 months and baseline and 12 months for each treatment group. A significance level of .05 was used for all comparisons.

RESULTS

Patient Characteristics

Twenty patients were included in each group. In 6 test and 4 control patients bilateral sinus procedures were performed and included in the analyses. The test therapy was proposed to 29 patients (9 patients refused the proposed interventions) while the control therapy was proposed to 38 patients (18 patients refused the proposed interventions).

The test group comprised 12 men and 8 women with a mean age of 42 years (range, 21 to 58 years). No patient had to be excluded because of lack of sufficient bone in the ulna.

The control group consisted of 11 women and 9 men with a mean age of 33 years (range, 27 to 56 years). The following donor sites were used: mental symphysis (11 patients), tibia (5 patients), and iliac crest (4 patients).

In each group 52 implants were placed in the grafted sinuses. The present study focuses on implants placed in grafted sinuses. The outcome of implants placed in nongrafted sinus bone is not reported.

No patient was lost to follow-up or withdrawn from the study. No prosthesis or study implant failed up to 1 year of function.

Complications

Different types of complications were observed, however, no complication had serious consequences for the patient.

No complications were recorded for the test sites. All the 3 complications in the control group occurred in the mental symphysis: edema with extensive bruises on the neck (1 patient); monolateral transitional paraesthesia, which lasted about 3 weeks (1 patient); and dehiscence of the flap, which healed after a few days (1 patient).

Intraoperative complications occurred at some implant sites: perforation of the sinus membrane during surgery occurred in 3 cases for the ulna group

Table 1 Comparison of Periotest and Osstell Mean Values Between the 2 Groups at Baseline, 6 Months, and 1 Year

	Ulna graft		Traditional graft		
	Mean	SD	Mean	SD	*P**
Periotest					
Baseline	−1.18	0.49	−1.55	0.69	.053
6 mo	−2.40	0.95	−2.79	0.89	.19
1 y	−2.63	0.67	−2.84	0.89	.39
Osstell					
Baseline	60.61	3.48	61.18	4.47	.65
6 mo	64.48	6.29	65.22	5.88	.70
1 y	66.49	5.00	66.66	4.38	.91

n = 20 for each group.
**t* test.

Table 2 Comparison of the Change in Periotest and Osstell Mean Values Between Baseline and 6 Months and Between Baseline and 1 Year

	Ulna graft			Traditional graft		
	Mean	SD	*P*	Mean	SD	*P*
Periotest						
Baseline to 6 mo	1.22	0.61	< .001	1.24	0.61	< .001
Baseline to 1 y	1.44	0.48	< .001	1.29	0.58	< .001
Osstell						
Baseline to 6 mo	−3.86	5.17	.003	−4.03	4.28	< .001
Baseline to 1 y	−5.88	4.18	< .001	−5.48	3.93	< .001

n = 20 for each group.

and 2 for the control group. In these cases a resorbable collagen barrier (Biomend) was placed in the sinus for containment of the particulated graft. The 2 groups did not differ significantly with respect to the number of complications that occurred.

Postoperatively at the implant site, a small flap dehiscence developed in 2 patients in the ulna group and in 1 patient in the control group. All dehiscences healed after a few days.

In 2 test-group patients where grafts containing 2 or 3 implants were used, the implants could not be positioned at the ideal angle for prosthetic rehabilitation (angle > 20 degrees), and individual abutments were cast.

At 6 months and 1 year postloading, there were no statistically significant differences between the groups with respect to implant stability measured by either Periotest or Osstell (Table 1). A statistically significant improvement ($P < .003$) of stability over time was observed for implants in both groups for both types of measurements (Table 2).

DISCUSSION

Controlled studies have major limitations when used to investigate the efficacy of therapeutic interventions. The operator is free to allocate patients to the treatment groups according to his preference (selection bias), which may lead to biased and erroneous conclusions. The technique in the ulna group was refined during the study, and the number of patients included in the present trial might have been too low to detect statistically significant differences among the techniques, if any. Therefore the present findings have to be considered with caution. Conversely, measurements were taken in a blinded fashion, all treated patients were accounted for with no exclusions, and no failures occurred in any of the groups. So it is possible to suggest the ulna grafts may offer an alternative to conventional sinus augmentation procedures. However, rigorous and well-conducted randomized controlled clinical trials (RCTs) are needed to quantify more precisely the advantages and disadvantages of this technique. Such trials should also include patient-centered outcomes such as patient preference.

The importance of patient preference regarding these types of interventions can also be appreciated by counting the numbers of patients who refuse the interventions. It was not the aim of this paper to evaluate why patients refused the intervention, but it is plausible to believe that 2 aspects played a major role: fear of the surgical procedures and cost. Nine patients of 29 to whom ulna implants were proposed refused the intervention. This is not a surprising finding, since it is reasonable to expect that not all patients would be willing to undergo such an "invasive" (from a dental perspective) procedure. However, it would be useful not only to know which is the most effective therapy but also which interventions would be most acceptable to patients, given similarity in efficacy and complications. Eighteen patients refused to undergo the control interventions. In another trial where graft material was to be harvested from the mandibular ramus, it was reported that about half the patients to whom the procedure was proposed refused to donate their own bone and had to be treated with an alternative procedure.[6]

The present investigation was designed to evaluate whether ulna implants could offer some advantages over conventional sinus lifting procedures. The

ulna implant technique was developed based on the impression that treatment times could be shortened and postoperative discomfort could be reduced for patients needing major bilateral sinus augmentation procedures. In addition, it is also possible to vertically augment the bone without the need of additional grafts or regenerative procedures, by placing the implant/bone ulna grafts supracrestally. This renders this technique more flexible than conventional sinus augmentation procedures.

The results of the present study failed to disclose any statistically significant differences between the 2 techniques in terms of success; success rates were very high for both groups. If these results are confirmed in additional trials, then the intervention able to shorten treatment time and reduce complications and postoperative discomfort would be the preferable one. Complications were few in both groups and could be managed without causing too much trouble for the patients. However, with respect to the various donor sites, more complications occurred for grafts harvested from the chin. This is in accordance with the literature,[9,10] and although no major complications occurred in the patients included in this trial, it was decided to discontinue to use the chin as graft donor site.

In 2 patients of the ulna group who received bone blocks containing 2 and 3 implants, the implants were inclined more than 20 degrees upon placement. It is interesting to observe that this problem was encountered during the treatment of the first and fourth patient, and this may underline the importance of the learning curve involved in any new procedure. The problem was solved by casting individual angulated abutments, and it could have been prevented by using surgical templates for placement of the blocks.

Two RCTs[6,11] evaluated bone substitutes as an alternative to autogenous bone for sinus augmentation in patients with less than 5 mm of alveolar bone remaining in the floor of the sinus. In a randomized clinical trial,[6] patients refusing to have their bone harvested were treated by using 100% bovine hydroxyapatite (Bio-Oss; Geistlich Biomaterials, Wolhusen, Switzerland). Only 10 patients were treated with this technique, but only 2 implants were lost, and all prostheses were successful after 1 year of loading.[6] In the other trial,[11] a β-tricalcium phosphate (Cerasorb; Curasan, Kleinostheim, Germany) was evaluated in 20 patients using a split-mouth design. Only 1 implant failed in each group. There were no statistically significant differences between the bone substitute and the autogenous bone graft up to implant loading. The main disadvantage with those procedures was that the bone substitute grafts were allowed to heal for about 9 months[6] and 1 year[11] before implants were functionally loaded. This period may be considered too long by some patients. It is possible to achieve similar results in just 3 months at the price of 1 additional minor intervention by placing the implants in the ulna. Placement of the implants in the ulna, harvesting, and placement in the sinus during a single surgical session may be investigated in a future trial, since this would eliminate the need of the re-entry surgical intervention and further shorten the treatment time.

Properly designed RCTs that include a sufficient number of patients are needed to establish the most effective therapeutic approach to rehabilitate patients with large pneumatized sinuses. Patient-centered outcome measures, patient preference, esthetics, and treatment times and costs also need to be evaluated. Long-term trials also are needed to assess whether the vertically augmented bone with the ulna grafts is maintained over time.

CONCLUSIONS

Based on the results of this comparative clinical trial, the novel technique of using the ulna as a graft donor site showed no statistically significant differences in prosthesis or implant success rate when compared to conventional sinus augmentation procedures. However, the ulna grafting procedure may shorten treatment time and vertically augment the bone surrounding the implants.

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REFERENCES

1. Brånemark PI, Gröndahl K, Öhrnell LO, et al. Zygoma fixture in the management of advanced atrophy of the maxilla: Technique and long-term results. Scand J Plast Reconstr Surg 2004;38:70–85.
2. Tong DC, Rioux K, Drangsholt M, Beirne OR. A review of survival rates for implants placed in grafted maxillary sinuses using meta-analysis. Int J Oral Maxillofac Implants 1998;13:175–182.
3. Wallace SS, Froum SJ. Effect of maxillary sinus augmentation on the survival of endosseous dental implants. A systematic review. Ann Periodont 2003;8:328–343.

4. Del Fabbro M, Testori T, Francetti L, Weinstein R. Systematic review of survival rates for implants placed in the grafted maxillary sinus. Int J Periodontics Restorative Dent 2004;24:565–577.
5. Wannfors K, Johansson B, Hallman M, Strandkvist T. A prospective randomized study of 1- and 2-stage sinus inlay bone grafts: 1-year follow-up. Int J Oral Maxillofac Implants 2000;15:625–632.
6. Hallman M, Sennerby L, Lundgren S. A clinical and histologic evaluation of implant integration in the posterior maxilla after sinus floor augmentation with autogenous bone, bovine hydroxyapatite, or a 20:80 mixture. Int J Oral Maxillofac Implants 2002;17:635–643.
7. Esposito M, Grusovin MG, Worthington HV, Coulthard P. Interventions for replacing missing teeth: Bone augmentation techniques for dental implant treatment. Cochrane Database Syst Rev 2006. Chichester, UK: John Wiley & Sons, 2006.
8. Esposito M, Worthington HV, Coulthard P. Interventions for replacing missing teeth: Dental implants in zygomatic bone for the rehabilitation of the severely deficient edentulous maxilla. Cochrane Database Syst Rev 2005. Chichester, UK: John Wiley & Sons, 2006.
9. Chiapasco M, Romeo E, Casentini P, Rimondini L. Alveolar distraction osteogenesis vs. vertical guided bone regeneration for the correction of vertically deficient edentulous ridges: A 1-3-year prospective study on humans. Clin Oral Implants Res 2004;15:82–95.
10. Roccuzzo M, Ramieri G, Spada MC, Bianchi SD, Berrone S. Vertical alveolar ridge augmentation by means of a titanium mesh and autogenous bone grafts. Clin Oral Implants Res 2004;15:73–81.
11. Szabó G, Huys L, Coulthard P, et al. A prospective multicenter randomized clinical trial of autogenous bone versus beta-tricalcium phosphate graft alone for bilateral sinus elevation: Histologic and histomorphometric evaluation. Int J Oral Maxillofac Implants 2005;20:371–381.