Localized Lateral Alveolar Ridge Augmentation with Block Bone Grafts: Simultaneous Versus Delayed Implant Placement: A Clinical and Radiographic Retrospective Study

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Purpose: *To retrospectively evaluate the 1-year outcome of implant therapy involving localized lateral alveolar ridge augmentation with block bone grafts, and to compare outcomes of implants inserted simultaneously with grafting or after a healing period.* ***Materials and Methods:*** *Consecutively treated patients undergoing alveolar ridge augmentation with autogenous intraoral block grafts before or simultaneous with implant placement between 2005 and 2010 in the Oral Surgery Unit of the University of Valencia were included. The selection of procedure (simultaneous vs delayed implant placement, donor site) was based upon the criterion of the surgeon and thorough evaluation of each patient. All grafts were obtained with piezosurgery. Complications related to augmentation, implant survival, implant success, and peri-implant marginal bone loss were assessed.* ***Results:*** *Forty-two patients were included; 45 sites were augmented and 71 implants were inserted (33 delayed and 38 simultaneously). Complications (temporary paresthesia, wound dehiscence with bone graft exposure, and exposure of osteosynthesis screw) occurred after bone harvesting in nine patients; four were in the simultaneous group and five were in the delayed group. Six grafts were not successful; four were lost and two provided insufficient bone (after resorption) for ideal implant placement. The implant survival rate was 98.5% (100% for simultaneous and 96.9% for delayed implants) and the implant success rate was 92.9% (89.5% for simultaneous and 96.9% for delayed implants). Average marginal bone loss 1 year after loading was significantly higher for simultaneously placed implants (0.69 ± 0.67 mm) than for delayed implants (0.20 ± 0.50 mm).* ***Conclusions:*** *In lateral bone atrophy, block bone grafts provided sufficient bone for implant therapy, with few complications. Both simultaneous and delayed implant placement yielded high implant survival and success rates. Average marginal bone loss was significantly higher around simultaneously inserted implants.* Int J Oral Maxillofac Implants 2013;28:846–853. doi: 10.11607/jomi.2964

Key words: *alveolar ridge augmentation, bone grafting, dental implants*

Localized lateral ridge augmentation is performed frequently with autogenous block bone grafts from intraoral donor sites to increase the height and/or width of the alveolar process before or concomitant with implant placement. The main criteria to consider when choosing the grafting procedure are the residual bone volume needed to allow correct implant positioning and angulation and the bone density needed to achieve primary implant stability.[1] Recently published systematic reviews of implants placed in laterally augmented sites show high rates of implant and prosthesis survival.[2,3] According to a recent review of Aghaloo and Moy,[4] implant survival may be a function of residual bone, rather than grafted bone, supporting the implant.

The purpose of the present retrospective study was to evaluate the 1-year outcome of implant therapy involving localized lateral alveolar ridge augmentation with autogenous block bone grafts, and to compare clinical outcomes following simultaneous and delayed implant

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placement. Complications related to the augmentation procedure were assessed, along with graft success, implant survival, implant success, prosthesis survival, and radiographic peri-implant marginal bone loss.

MATERIALS AND METHODS

The present study is reported in accordance with the STROBE statement.[5]

Patients

Consecutively treated patients who underwent localized lateral alveolar ridge augmentation with autogenous intraoral block bone grafting before or at the time of implant placement between 2005 and 2010 in the Oral Surgery Unit of the University of Valencia were included in the study. All surgical procedures were performed by the same surgeon, who had extensive clinical experience in regenerative procedures. Patients were fully informed about the surgical procedures and treatment alternatives, and signed informed consent was provided. Preoperative analysis included a complete medical history and clinical and radiographic examination. Patients were included if they were partially or completely edentulous with severe atrophy of the alveolar ridge (Cawood and Howell Class IV, ie, knife-edge ridge with adequate height but inadequate width of 4 mm or less). The selection of the performed procedure (grafting simultaneous with or prior to implant placement, choice of donor site) was based upon intraoperative evaluation of each case. The width of the bone ridge was assessed, and if the implants could be expected to achieve primary implant stability with adequate positions and angulations (bone ridge width between 3 and 4 mm), they were inserted at the time of bone grafting. If the alveolar ridge was narrower than 3 mm, primary implant stability was considered difficult or impossible to achieve, and implants were placed in a subsequent procedure. A delayed implant placement approach was also used in cases of high esthetic risk (anterior maxilla).

Bone grafting was not performed if a patient had systemic or local conditions to contraindicate it (eg, previous chemotherapy, previous irradiation of the head and neck region, progressive periodontitis, immunosuppression, human immunodeficiency virus infection), had poor oral hygiene, or was pregnant. Oral hygiene was assessed in the first appointment and classified into good, average, or poor. Cases of vertical alveolar ridge augmentation or those with incomplete protocol information were excluded from the study. No more than 10 days before bone grafting, oral hygiene instructions and professional debridement were delivered to all patients.

Surgical Procedures

Bone Graft Harvesting. All regions were augmented with autogenous block bone grafts harvested from intraoral sites: the lateral aspect of the mandibular ramus, the retromolar area, the mandibular symphysis, the site adjacent to the defect, or the maxillary tuberosity. All grafts were obtained using the ultrasonic Piezon Master Surgery System (EMS Electromedical Systems).

When the lateral ramus was used as the donor site, an incision was made from the anterior part of the ramus and continued into the alveolar sulcus of the mandibular second and first molars. The lateral part of the ramus was exposed, and a mainly cortical bone graft was harvested from the lateral cortex of the ramus, as described by Misch.[6] The technique to obtain bone from the retromolar area was similar to that used for the lateral ramus, but the distal releasing incision was shorter, and bone was obtained from the region corresponding to the third molar. Bone from the mandibular symphysis was harvested through an incision from canine to canine, about 5 mm below the mucogingival line. The anterior part of the mandible was exposed and a monocorticocancellous bone block was harvested, with a margin of 5 mm from the teeth apices, the basal border of the mandible, and the mental foramina maintained for safety. Blocks from the maxillary tuberosity were harvested by performing a crestal incision that began at the tuberosity and continued into the alveolar sulcus of the maxillary second or first molar.

Lateral Augmentation. The surgical procedures for lateral augmentation performed before or at the time of implant placement are illustrated in Figs 1 and 2, respectively.

The surgery was performed under local anesthesia (4% articaine, 1:100,000 adrenalin; Inibsa) and intravenous conscious sedation with 1% propofol solution. An incision was initially made slightly palatal/lingual to the alveolar crest. One or two releasing incisions were made at adjacent teeth, and a mucoperiosteal flap was raised. The exposed alveolar bone was curetted to remove all soft tissues.

The cortical bone at the recipient site was perforated at multiple sites with a thin cylindric bur to increase bleeding. The bone block was adjusted to the bone contour at the recipient site and fixed with one or two osteosynthesis screws (Osteoplac, Donostia) to immobilize the graft. Moreover, the block grafts were always covered with a thin layer of particulate autogenous bone that was obtained from the donor site with a scraper and mixed with beta-tricalcium phosphate (Kera-Os, Keramat). The augmented site was further protected with a textured collagen membrane (Lyostypt, B Braun, Aesculap). Periosteal incisions were made to allow flap mobilization and tension-free primary wound closure. Flaps were closed with horizontal sutures (Polisoft 4/0, Sweden & Martina).

Figs 1a to 1i *A bone graft is harvested from the retromolar region and implants are placed after healing.*

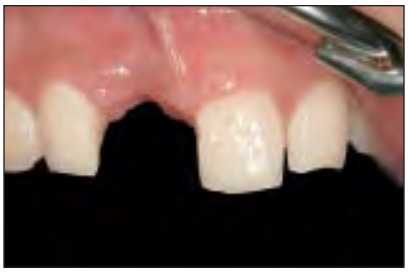

Fig 1a Preoperative frontal view.

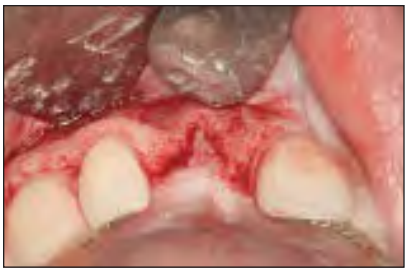

Fig 1b Bone defect visualized after flap elevation.

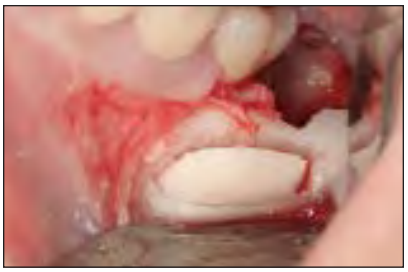

Fig 1c A block bone graft was harvested from the retromolar region; simultaneous surgical extraction of the mandibular left third molar had been performed.

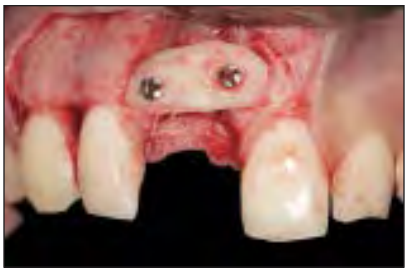

Fig 1d Fixation of the block bone graft with osteosynthesis screws.

Fig 1e Delayed implant insertion in the maxillary right central incisor position.

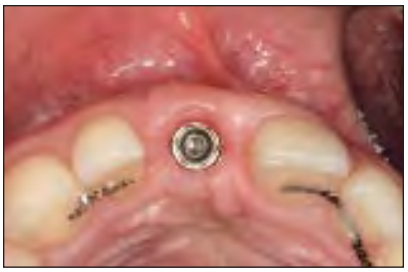

Fig 1f Healed soft tissues 3 months after implant insertion.

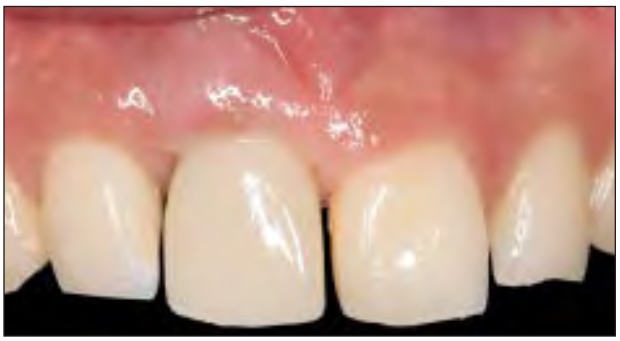

Fig 1g The definitive prosthesis was placed 4 months after implant insertion.

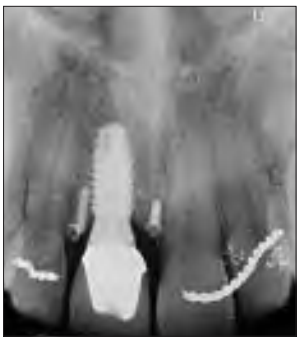

Fig 1h Intraoral radiograph taken at prosthesis placement.

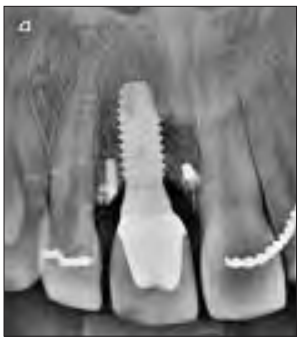

Fig 1i Twelve-month control intraoral radiograph.

Implant Placement. TSA Avantblast surface implants (Phibo Dental Solutions) were placed using a standard procedure according to the guidelines of the manufacturers. Implants were placed simultaneously with the block bone graft or after an average healing period of 6.8 months (range, 5 to 8 months). All implants in both groups were placed with adequate primary stability (≥ 35 Ncm). According to a two-stage protocol, cover screws were placed, and flaps were closed with Polisoft 4/0 sutures (Sweden & Martina).

All patients received postoperative antibiotic treatment: amoxicillin 500 mg/125 mg clavulanic acid three times for 1 week after block bone grafting, and amoxicillin 500 mg three times daily for 1 week after delayed implant placement with particulate bone grafting. Ibuprofen (600 mg, three times daily) was prescribed to all patients to be taken as required. Patients were instructed to rinse with 0.2% chlorhexidine digluconate three times daily for 2 weeks after bone grafting and implant placement surgeries. Patients were not allowed to use removable prostheses for 3 weeks after bone grafting. A soft diet was recommended for 1 week, and patients were advised to avoid brushing and trauma on the surgical sites. Sutures were removed 2 weeks postoperatively. Stage-two surgeries were performed 2 months after implant placement, and the definitive removable or fixed prostheses were placed 1 month later.

Figs 2a to 2g *Implant insertion in the mandibular posterior region and simultaneous block bone graft harvested from adjacent area.*

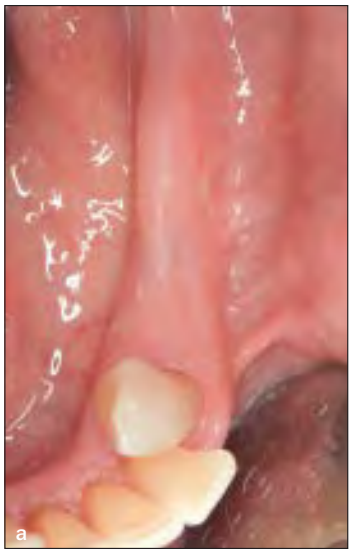

Fig 2a Preoperative occlusal view of the atrophic posterior mandible.

Fig 2b Lateral atrophy of the graft has led to buccal dehiscences of the implants in the mandibular left first and second molar positions.

Fig 2c A block bone graft is harvested from the area distal to the implants.

Fig 2d Fixation of the block graft with an osteosynthesis screw.

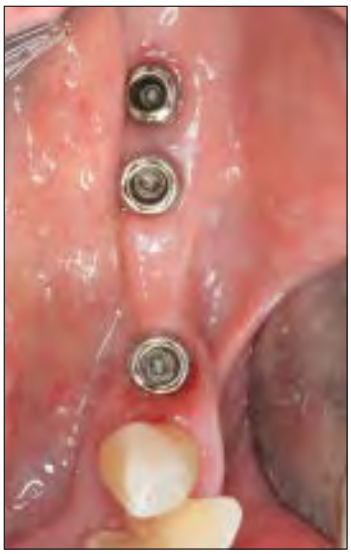

Fig 2e Healed soft tissues at the 3-month follow-up.

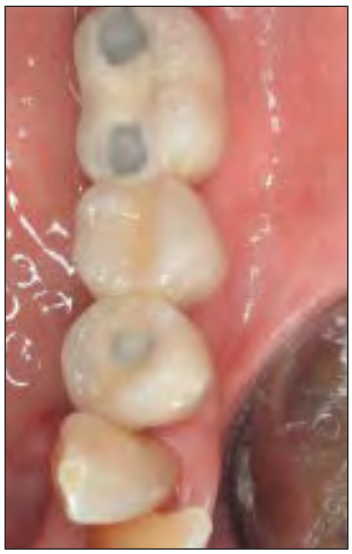

Fig 2f Prosthesis placement 4 months after implant insertion.

Fig 2g Intraoral radiograph at implant loading.

Follow-up Protocol and Outcome Measures

All patients were included in a maintenance program involving annual examinations. The following outcome measures were recorded:

- *Complications related to the augmentation procedure:* sensory disturbances (paresthesia, hypoesthesia); wound dehiscence with bone graft exposure or exposure of the osteosynthesis screw without graft exposure; infection; graft loss.
- *Graft success:* The graft was considered successful when there was no infection or graft loss and sufficient bone volume was obtained to allow implant placement.
- *Implant survival:* Implant failure was defined as implant mobility or removal of stable implants because of progressive peri-implant marginal bone loss or infection.
- *Implant success:* Implant success was based on the clinical and radiographic criteria of Buser et al[7]: *(1)* absence of clinically detectable implant mobility, *(2)* absence of pain or any subjective sensation, *(3)* absence of recurrent peri-implant infection, and *(4)* absence of ongoing radiolucency around the implant after 6 and 12 months of prosthetic loading.
- *Prosthesis survival:* Failure was defined as a prosthesis that could not be placed or had to be removed because of implant failure.

Table 1 Description of Patients, Implants, and Bone Grafting Procedures

	Time of implant placement		
	Simultaneous	Delayed	Total
No. of patients	20	22	42
No. of augmented sites	20	25	45
No. of implants	38	33	71
Donor site			
Chin	2	2	4
Mandibular ramus	6	4	10
Retromolar area	7	3	10
Adjacent site	4	11	15
Maxillary tuberosity	1	5	6

- *Radiographic peri-implant marginal bone loss:* Intraoral radiographs were made at prosthetic loading (baseline) and at the 1-year control visit using the XMIND intraoral system (Groupe Satelec-Pierre Rolland) and an RVG intraoral digital receptor (Dürr Dental) with the aid of Rinn XCP (Dentsply Rinn) to achieve parallelism. If the bone level around the study implants was not clearly visible, a new radiograph was made. The distance from the implant-abutment connection to the peri-implant marginal bone level was measured to the nearest 0.5 mm mesially and distally. Bone loss was calculated by comparing the change in bone level between the baseline and the 1-year control radiographs.

Statistical Analysis

The Fisher exact test was used to evaluate differences between the groups with respect to success, survival, and complications with implants, bone grafts, and patients. To determine whether the donor site influenced the outcome of the graft, the statistical relationship between donor site and graft success was analyzed. Because of the limited sample size, the chi-squared test could not be used, so the Fisher exact test was used to separately compare proportions of graft success/failure between each donor site location and the other locations. The necessity of particulate bone graft to cover dehiscences or fenestrations at delayed implant insertion was considered a variable related to block bone graft resorption. In this case, maxillary donor sites (tuberosity and adjacent sites) and mandibular donor sites (chin, mandibular ramus, and retromolar areas) were grouped together, and the statistical relationship of this variable with the donor site location (maxillary or mandibular) was studied using the chi-squared test. The Mann-Whitney test was used to compare bone loss between groups. The statistical power for this test was 80.8% to detect an effect of 0.7 with a confidence interval of 95% and alpha set at .05. Statistical analyses were completed using SPSS 15.0 software (IBM).

RESULTS

Sixty-six patients were treated with oral implants and block bone grafts. Twenty-one patients were excluded because the bone grafts were used to augment both the width and height of the alveolar bone and three were excluded for incomplete protocols.

The final study sample included 42 patients (28 women, 14 men) with a mean age of 48 ± 17.1 years (range, 21 to 82). Oral hygiene was good in 29 patients and average in 13 patients. Twenty-four patients were nonsmokers, 12 smoked up to 10 cigarettes per day, and 6 smoked between 11 and 20 cigarettes per day.

A total of 45 regions were augmented and 71 implants were inserted (33 delayed and 38 simultaneously). All regions were augmented with autogenous block bone grafts harvested from intraoral regions: the lateral aspect of the mandibular ramus (10 regions, 22.2%), the retromolar area (10 regions, 22.2%), the mandibular symphysis (4 regions, 8.9%), a site adjacent to the defect (15 regions, 33.3%), and the maxillary tuberosity (6 regions, 13.3%) (Table 1).

Complications Related to Augmentation

Complications at the recipient site occurred in nine patients (four in the simultaneous implantation group and five in the delayed implantation group). Differences in the proportion of complications between both groups were statistically insignificant ($P = .561$). Complications were more frequent in men (75.0%) than in women (25.0%), and this difference was statistically significant ($P = .013$). No relevant differences were detected with respect to age, hygiene, or smoking habits. No postoperative complications at donor sites were registered.

In patients who received implants simultaneously with bone grafts, complications were wound dehiscence with graft exposure (three patients) and exposure of the osteosynthesis screw without graft exposure (one patient). Patients with exposed grafts were told to rinse with chlorhexidine 0.2% three times/day for 3 to 4 weeks; one site re-epithelialized, and two grafts were lost.

In the delayed implant placement group, temporary hypoesthesia of the chin occurred in one patient after the graft procedure; the block bone graft had been obtained from the mandibular symphysis. Vitamin B complex (30 mg/day for 2 months) was administered, and the symptoms had completely disappeared

Table 2 Statistical Analysis of the Relationship Between Donor Site Location and Graft Success

Donor site	Success	Failure	*P**
Chin	2	2	.080
Mandibular ramus	10	0	.312
Adjacent site	14	1	.647
Maxillary tuberosity	2	1	.356
Retromolar area	11	2	.999

*Fisher exact test.

Table 3 Statistical Analysis of the Relationship Between Donor Site Location (Maxilla/Mandible) and the Need for Particulate Bone Grafting at Delayed Implant Placement

	Particulate grafting needed?		
Donor site	Yes	No	*P*
Maxilla	13	3	.032
Mandible	7	10	

*Chi-squared test.

after 2 months. Wound dehiscence with bone graft exposure occurred in four patients with five grafted sites; after treatment with chlorhexidine, three sites re-epithelialized with no further problems and two grafts were lost.

Graft Success

Six bone grafts (13.3%) were not successful; four grafts were lost and two did not create sufficient bone for ideal implant placement. The failed blocks were unstable upon retrieval. In three cases the screws were still fixed, and in one case the screws were also unstable. Resorbed blocks were stable.

In the patients with simultaneous implant placement, two grafts were lost, but neither of these bone graft failures involved failure of the implants. In the delayed implantation group, two grafts were lost in one patient, and two patients needed a new block bone graft prior to implant placement because the bone volume obtained was not sufficient for ideal implant placement; wound dehiscence had occurred in all four grafts during the postoperative period.

No significant relationships were found between donor site location and graft success (Table 2). Despite the successful outcome of the rest of the block bone grafts, particulate bone graft was used on the buccal for 22 of the 33 delayed implants during the insertion procedure to cover dehiscences and fenestrations and ensure a satisfactory result. More cases of maxillary than mandibular donor sites needed particulate bone graft at delayed implant placement; the difference between the maxilla and the mandible was statistically significant (Table 3; $P = .032$).

According to the defined criteria, the graft success rate was 86.7% (84.0% in the delayed group and 90.0% in the simultaneous group); this difference was not statistically significant ($P = .251$).

Additional Outcomes

One implant failed in the delayed placement group (before loading) and none failed in the simultaneous placement group. However, 1 year after loading, five implants in two patients in the simultaneous implantation group showed severe marginal bone loss (3 to 7 mm); these implants remained in situ until the end of the follow-up period but were not considered successful according to the criteria of Buser et al.[7] The differences in implant success and survival rates between groups were not statistically significant ($P = .465$ and $P = .135$, respectively). Average marginal bone loss after 1 year of loading was 0.69 ± 0.67 mm for simultaneously inserted implants in those patients in whom the bone graft was successful, and average bone loss was 0.20 ± 0.50 mm for patients with successful grafts who received delayed implants; this difference was statistically significant ($P < .001$). All prostheses could be placed and none had to be removed, yielding a 100% prosthetic success rate. No significant differences were found in implant success and survival rates or average marginal bone loss with respect to demographic factors (age, sex) or habits (smoking, hygiene).

DISCUSSION

This study was designed to retrospectively evaluate after 1 year of follow-up whether implants placed simultaneously with intraoral bone grafts achieved outcomes equivalent to those of implants placed after consolidation of the bone graft. The results of this study suggest that both procedures yield high implant survival rates, although simultaneously placed implants had a slightly lower success rate than delayed implants. Both techniques achieved the planned treatment outcome, but the placement of implants simultaneously with block bone grafts did so more quickly.

Implant insertion simultaneous with block grafting offers the advantages of shortened treatment time and a reduction in the required number of surgical interventions. The most important issues to be addressed are primary stability and optimal positioning of the implants; if insufficient bone remains to provide primary stability and proper implant positioning, delayed implant placement is typically the appropriate treatment.[1]

When a block bone graft is performed, resorption always occurs. Although both intraoral maxillary and mandibular bone have an intramembranous origin, the different anatomies of these regions result in different graft morphologies and properties. Mandibular bone grafts (ie, ramus and chin), which are primarily corticocancellous or more cortical bone, exhibit little volume loss and show good incorporation after short healing times.[8] In contrast, the quality of bone in the posterior maxilla, especially in the maxillary tuberosity region, consists mainly of a thin cortical layer and a mixture of marrow spaces, adipose tissue, and a small amount of vital osteogenic cells.[9] To prevent bone resorption during the healing period, the use of membranes has been advocated.[10,11] In the present study, particulate alloplastic graft material and collagen membranes were used to protect the grafts. According to the results of this study, more than half of the delayed implants that needed particulate bone graft to cover peri-implant defects at implant insertion had been placed in sites previously regenerated with maxillary bone grafts, and this difference was statistically significant. In addition, two patients required a second block bone graft prior to implant placement because the bone gain obtained was not sufficient for ideal implant placement; in these cases grafts had been obtained from the maxillary tuberosity or a maxillary adjacent site to the bone defect. The present study did not include a control group that did not receive synthetic particulate bone in addition to the block graft, so this study provides insufficient evidence on the effectiveness of this technique to prevent resorption.

Complications at the recipient site are often caused by problems with soft tissues, such as insufficient wound closure, flap necrosis, and dehiscence with exposure of the bone graft. To minimize the risk of dehiscence, it is necessary to achieve tension-free wound closure.[12] The treatment of prematurely exposed bone is complicated, since resuturing the flap may lead to increased exposure of the graft. Von Arx and Buser[10] recommended the application of chlorhexidine solution or gel several times a day to reduce the bacterial load; if re-epithelialization does not occur, the exposed bone is often removed with rotary instruments.[13] In the present study, eight dehiscences were found; five re-epithelialized without problems after application of chlorhexidine (0.2% three times/day for 3 to 4 weeks) and three bone grafts were lost. In two cases, the augmentation procedure was a failure because the bone volume obtained was not sufficient to allow the planned implant therapy and a new block graft was necessary; this was probably associated with the wound dehiscence with membrane and graft exposure that had occurred in both cases. Sharaf et al[14] concluded that the evidence suggests that a single preoperative dose of antibiotics or a single preoperative dose and a short-term postoperative antibiotic regimen might reduce early implant failure and that clinicians should minimize the ubiquitous use of antibiotics in healthy patients with a low risk of postoperative infection. However, the clinician's own judgment of each patient is essential in tailoring antibiotic use to prevent implant infection and failure. In this study, 2 g amoxicillin and 125 mg clavulanic acid were administered preoperatively, and all patients received postoperative antibiotic treatment with 500 mg amoxicillin/125 mg clavulanic acid three times daily for 1 week.

The most common complication at graft donor sites according to the literature is temporary mental paresthesia, especially when the graft comes from the chin or mandibular ramus.[15–17] The use of piezoelectric techniques minimizes the risk of complications associated with block bone graft harvesting.[18] In the present study, all grafts were obtained using piezosurgery; despite this, one patient experienced hypoesthesia of the alveolar inferior nerve, which had disappeared by 6 months.

Several studies report high survival and success rates for implants placed in block bone grafts.[1,19–28] However, few studies have compared the survival rate of implants (whether placed simultaneously or delayed) with respect to the block bone grafting procedure.[27,28] McCarthy et al[28] inserted 36 implants (33 delayed and 3 simultaneous), and one simultaneous implant failed, yielding an overall survival rate of 97.1%. Lekholm et al[29] stated that more implants were lost when they were inserted simultaneously (23%) than when they were placed in a subsequent procedure (10%). In the present study, a higher survival rate was obtained for implants inserted simultaneously (100%) than for those placed after graft healing (96.9%). However, marginal bone loss was significantly greater for implants inserted simultaneously and, according to the criteria defined by Buser et al,[7] the success rate for simultaneously placed implants was lower (89.5%) than that achieved for delayed implants (96.9%).

Nevertheless, trials with larger sample sizes and longer follow-up periods are needed to confirm or reject these findings. On the other hand, all procedures were performed by the same oral surgeon, who had extensive clinical experience in regenerative procedures, which might limit extrapolation of the results.

CONCLUSIONS

In lateral bone atrophy, intraoral block bone grafts obtained with piezosurgery were successful in providing sufficient bone for implant therapy and were associated

with few complications. Both simultaneous and delayed implant insertion protocols yielded high implant survival and success rates, but average marginal bone loss was significantly higher around simultaneously inserted implants.

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