Marginal Bone-Level Alterations at Implants Installed in Block versus Particulate Onlay Bone Grafts Mixed with Platelet-Rich Plasma in Atrophic Maxilla. A Prospective 5-Year Follow-Up Study of 15 Patients

Amir Dasmah, DDS;* Andreas Thor, DDS, PhD;† Annika Ekestubbe, DDS, PhD;‡ Lars Sennerby, DDS, PhD;§ Lars Rasmusson, DDS, PhD¶

ABSTRACT

Background: Extensive atrophy of the alveolar process may require a bone-grafting procedure prior to implant treatment. Autogenous bone grafts from the iliac crest, used as onlay block and particulate bone, have been used together with sinus-lift procedure in order to rehabilitate patients with extremely resorbed maxillae. However, there are to our knowledge no 5-year follow-up studies evaluating the extent of bone-level change in patients treated with respectively block and particulate autogenous bone grafts.

Purpose: The purpose of this prospective clinical study was to conduct a 5-year follow-up analysis with focus on bone-level alteration in block versus particulate onlay bone grafts.

Material and Methods: Fifteen out of originally 19 patients who were treated with iliac bone grafts and oral implants in the maxilla have been followed through the first 5 postoperative years. In a first study conducted on 19 patients, the role of platelet-rich plasma in conjunction with autogenous bone was evaluated. In this 5-year follow-up study, the marginal bone alterations have been documented at base line, 1 year and 5 years of loading to the nearest 0,1 mm at mesial and distal surfaces of the implants. Two implants were installed on each side of the midline in either block or particulate bone grafts giving test and control sides in each patient. Additionally, two implants on each side were installed in residual bone/grafted sinus floor.

Result: Marginal bone alteration in the anterior maxilla appeared larger at the side augmented by block bone at baseline, and after 1 and 5 years of loading, but the change was not statistically significant. Moreover, there was a significantly higher degree of marginal alteration during the first year of loading, compared with the examinations after 5 years.

Conclusion: The present follow-up study showed that there is no significant difference in the extension of resorption between block- and particulate autogenous bone grafts over a 5-year period. Most of the resorption occurred during the first year in function.

KEY WORDS: bone formation, bone graft, oral implants, platelet-rich plasma

*Research fellow, Department of Oral & Maxillofacial Surgery, The Sahlgrenska Academy, University of Gothenburg, Sweden; resident, The Maxillofacial Unit, Söder Hospital, Stockholm, Sweden. †associate professor, Department of Surgical Sciences, Oral & Maxillofacial Surgery, Uppsala University Hospital, Uppsala, Sweden. ‡associate professor, Department of Oral & Maxillofacial Radiology, Institute of Odontology, The Sahlgrenska Academy, University of Gothenburg, Sweden. §professor, Department of Oral & Maxillofacial Surgery, The Sahlgrenska Academy, University of Gothenburg, Sweden. ¶professor, head, Department of Oral & Maxillofacial Surgery, The Sahlgrenska Academy, University of Gothenburg, Sweden

Reprint requests: Dr. Amir Dasmah, Maxillofacial Unit, Stockholm Söder, Hospital, 118 83 Stockholm, Sweden; e-mail: amirpasha.dasmah@sodersjukhuset.se

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INTRODUCTION

Rehabilitation of edentulous patients with oral implants can be limited because of the lack of sufficient bone volume in order to gain implant stability and gain good prognosis of future fixed restorations. Several grafting materials and techniques have been used with varying clinical outcomes.[1–10] According to the literature, the gold standard is still autogenous bone grafts[1,11–13] even though graft resorption is often encountered during healing.[14,15] In order to reach a successful clinical outcome with integration and survival of implants, newly grafted bone have to be incorporated in the recipient site.

It has been documented that the reasons for resorption are related to factors such as donor site, handling and the size of the graft, surgical technique, time of implant placement, healing protocols, prosthetic factors, and patient related factors.[16,17]

Grafts are placed on the anterior maxilla as onlay bone grafts attached by titanium screws.[16] However, there is a risk for soft-tissue ingrowth between the maxilla and the grafted bone block, which may result in fibrous tissue incorporation in the graft. In order to avoid this situation, some clinicians use particulate bone grafts in between the bone block and the maxilla as space fillers. The use of particulate bone is clearly more homogeneous, but may be less resistant to soft-tissue pressure and accidental forces during healing.[16]

In order to stimulate the healing process of the grafted bone, the use of platelet-rich plasma (PRP) from patient's own blood has been presented by Marx and colleagues[18] and, more recently, Thor and colleagues[16] It has been suggested that some growth factors in platelets such as transforming growth factor, platelet-derived growth factor, and vascular endothelial growth factors could promote the healing process and eventually prevent the resorption course.

In a prospective clinical study, Thor and colleagues[16] evaluated whether PRP in combination with particulate bone graft used in grafts to the maxilla could improve the integration and clinical function of oral implants. In the anterior maxilla, particulate bone mixed with PRP was compared with onlay block bone without additional PRP. Furthermore, in the posterior part of the maxilla, particulate bone grafts with or without PRP was placed as sinus inlays. PRP and non-PRP sites were evaluated and compared regarding implant survival rate, marginal bone level, and implant stability using resonance frequency analysis (RFA) during 1 year in function. It was concluded that high-implant survival rates and stable marginal bone levels could be observed after 1 year of loading of the implants in the maxilla with or without PRP with autogenous bone grafts.

In a clinical study conducted by Johansson and colleagues,[15] the changes in volume of autogenous buccal onlay and particulate sinus inlay grafts in the atrophic maxilla was evaluated after 6 months. It was demonstrated that the reduction in the volume of bone was the same regardless of the method used for grafting. The purpose of the present 5-year follow-up, of the same patient material earlier evaluated after 1 year in function,[16] was primarily to radiographically evaluate the marginal bone alteration of the grafted bone and compare onlay block bone versus particulate bone grafts at base line, 1 year and 5 years on the anterior maxilla. Furthermore, stability measurements using RFA was conducted at baseline, at abutment surgery, and after 1 and 3 years of loading.

MATERIALS AND METHODS

Patients

Fifteen patients (2 men and 13 women; mean age 58 years, range 35–75 years) with severe resorption of the maxilla were reconstructed with iliac bone grafts and oral implants and a fixed full bridge. The patients were presurgically evaluated by clinical and radiographic examinations. In order to evaluate the extent of the horizontal and vertical bone deficiencies in the anterior and posterior maxilla, computed tomographic scans were used and the available bone volume was assessed. Inclusion criteria were severely edentulous maxilla and bone atrophy, vertical bone height of 2 to 5 mm under the maxillary sinuses and/or an alveolar crest width of less than 3 mm in the area planned for placement of dental implants. Also patients smoking less than 10 cigarettes/day, with no alcohol abuse and with an age between 20 to 75 years old were included in the study. Exclusion criteria were acute illness, ongoing chemotherapy, ongoing or recent (within 3 years) radio therapy, and i.v. bisphosphonate treatment. One patient had mild osteoporosis; none of the patients were diabetic. Prior to treatment, 12 patients were smokers (<10 cigarettes/day). One patient smoked during the period from bone grafting to the abutment connection.

Study Design

Using a split-mouth design, one side of the anterior maxilla was grafted with particulate bone graft with added PRP (test). At the contralateral side (control), 1–2 blocks of bone were stabilized with fixation screws. In addition, particulate bone was placed bilaterally as sinus inlays, the left side with supplemented PRP and the right side without; however, the result has been presented previously and is not within the scope of this study. Ten of the patients received particulate bone grafts to the nasal floor with added PRP. No randomization was performed. Oral implants were installed after 6 months of healing and after additional 6 months; abutment surgery was performed.

The patients underwent radiological examinations at baseline (prosthetic treatment), after 1 and 5 years of loading. The RFA was conducted at implant placement, abutment surgery, and after 1 and 3 years of loading.

Presurgical Care

Antibiotics were given perioperatively at the start of the bone graft surgery with benzylpenicillin (3 g × 3) or clindamycin (600 mg × 3) and for the following 24 hours. Patients received 2 g of phenoxymethylpenicillin preoperatively at the time of implant installation as a single dose.

PRP Preparation

The preparation of PRP was performed using a Sequestra 1000® gradient density cell separator (Medtronic, Minneapolis, MN, USA) in the operating room. After withdrawal of 450 mL whole blood, 63 mL citrate phosphate dextrose (Terumo Corp, Tokyo, Japan) was added in order to achieve anticoagulation. The blood was then separated into PRP and the red blood cells in a platelet poor plasma (PPP) as described by Marx and colleagues[18]

The PPP with the red blood cells were transfused back to the patients. In order to obtain autologous thrombin, CaCl were added to the anticoagulated PRP and a gel mass was formed. The gel was then gently squeezed and the solution extracted from it was used as autologous thrombin. Finally, PRP was mixed with autologous thrombin in a syringe that produced a gel, which could be used with the bone graft.

Harvesting of the Bone Graft and the Grafting Procedure

Under general anesthesia, corticocancellous bone graft were harvested from the right (n = 17) and left (n = 2) anterior iliac crest. A bone mill (Tessier Osseous Microtome®, Stryker Leibinger, Frieburg, Germany) was used in order to particulate the harvested bone graft, which was mixed with PRP before delivery to the recipient sites.

Bone Blocks Used as Onlay Graft (Control). The recipient part of the maxilla was freed from the periosteum and prepared by a small round bur until small spots of bleeding were observed. A corticocancellous bone block from the anterior aspect of the iliac crest was harvested and placed on the right frontal subnasal area of the maxilla retained by a minimum of two 1.7 titanium screws (6–13 mm lengths) for securing and stabilizing the graft in order to avoid any micromovement (Figure 1, A and B).

Particulate Bone Used as Onlay Graft (Test). The maxilla was freed the same way as on the control side and a moldable mass of particulate bone mixed with PRP was thereafter placed onto the recipient site (Figure 1, A and B).

In order to gain a full, tension-free coverage of the grafted area, an incision was made through the periosteum on both sides and the flap was elongated and closed by resorbable sutures (Vicryl®, Johnson & Johnson AB, Sollentuna, Sweden).

Particulate Bone Used as Sinus Inlay. After elevation of a full thickness flap via a midcrestal incision and exposure of the maxillary bone, a cortical window was outlined on the frontal–anterior aspect of the maxillary sinus wall bilaterally. The Schneiderian membrane was gently lifted and pushed medially together with the bony window. Particulate bone mixed with PRP was placed and compressed in the anterior and lower part of the left maxillary sinus and the right side was grafted with the same procedure, using particulate bone without PRP.

Postsurgical Care

Patients received a coverage of prophylactic antibiotic cure during 10 days after grafting surgery with either phenoxymethylpenicillin (1 g × 3) and metronidazole

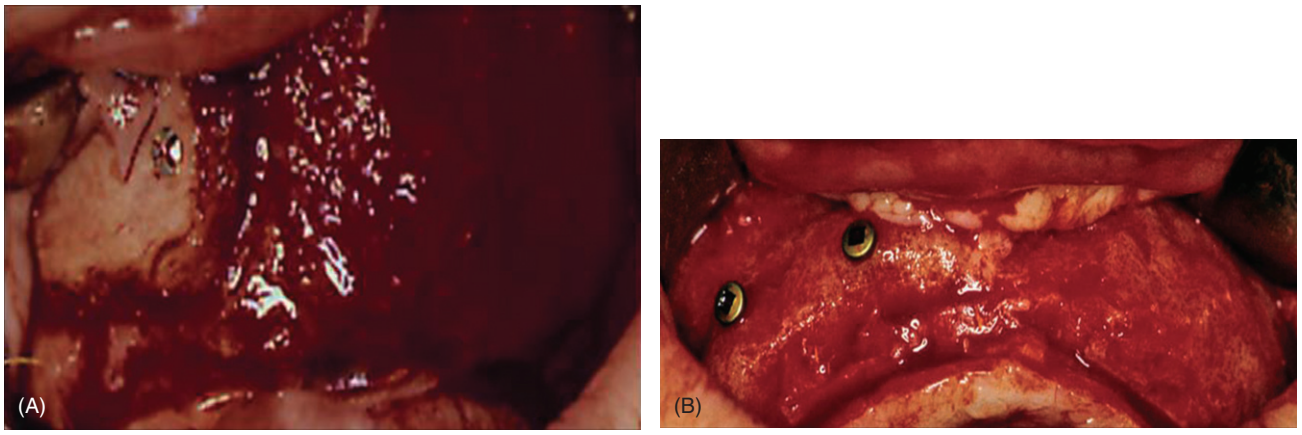

Figure 1 (A) Clinical perioperative picture of maxilla augmented by cortical- and particulate bone grafts. (B) Corresponding picture after 6 months of healing.

(400 mg × 3) or clindamycin (300 mg × 3). Phenoxymethylpenicillin 1 g three times per day for 5 days were given postoperatively after implant surgery. (One patient received clindamycin 300 mg × 3 because of previous allergic symptoms from phenoxymethylpenicillin.)

Patients were prescribed acetaminophen with codeine or nonsteroidal anti-inflammatory drug as analgesia for 1–2 weeks following the surgical procedures.

Dentures were not used during the first month following the grafting procedure and for 10 days after the implant placement. Viscogel® (Dentsply, York, PA, USA) was used in order to trim the dentures for better stability and balance.

Implants

Six months after the grafting procedure, surface-modified oral implants with titanium dioxide (TiOblast™, Astra Tech AB, Mölndal, Sweden) were installed. Eight implants were installed in each patient. After 6 months of healing, abutments were placed in all cases.

RFA

The stability of the implants was measured by RFA (Osstell™, Integration Diagnostic AB, Gothenburg, Sweden) after fixture installation, at abutment connection, and after 1 and 3 years. A transducer was attached to the implants, and measurements of implant stability, using Implant Stability Quotient (ISQ) units where one ISQ correspond to 50 Hz, was performed. To be able to evaluate RFA, the bridges had to be removed. This was done in all 15 patients after 1 year but only in ten patients after 3 years because five patients refused follow-up.

Radiographic Examinations

Radiographs were taken at the Department of Dental Radiology, Eastman Institute, Stockholm, Sweden using parallel intraoral techniques in order to measure the marginal bone level at baseline (after completion of the prosthetic treatment), after 1 year and 5 years of loading. There were four dropouts for the 5-year radiographic examination. However, there was no implant losses reported.

One observer, a specialist in oral radiology with long experience from implant radiology, performed the evaluation of all radiographs. The marginal bone height and bone-level change over time was assessed at the mesial and distal surface of each implant by measuring the distance between the reference point and the bone level of each implant (Figure 2).

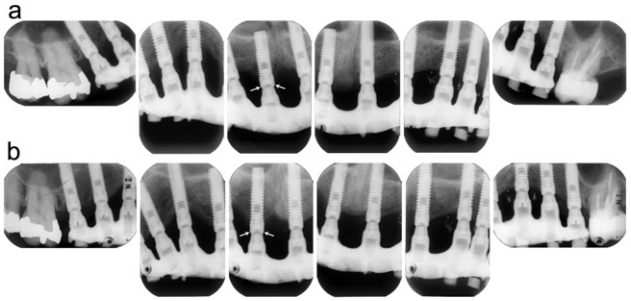

Figure 2 Radiographs from one of the patients in the study at (A) 1 year control and (B) 5 years control. The reference of the fixture used for bone-level measurements is marked with arrows.

The upper most point of the vertical section of the implants was regarded as the reference point. Further, signs of radiographic changes at the bone-implant contact zone indicating loss of osseointegration and signs of problems correlated to the mechanical components of the implants were also registered. Bone-level measurements were performed to the nearest 0.1 mm by the use of a magnifying lens (x7) and a mean value of the mesial and distal measurements were calculated per implant. The error of the radiographic measurements was determined by double recordings of one randomly selected implant per patient from the 5-year follow-up examination. The mean difference between the two readings was set as the value of resorption.

Statistics

The Wilcoxon signed-rank test was used for statistical analysis and a difference between test and control was considered as significant if $p < .05$.

RESULTS

Clinical Follow-Up

According to data presented by Thor el al.[16], there were only two fixtures in two patients found mobile at abutment surgery and consequently removed. The lost implants were both in the sinus area and thus not included in this study. No additional failures were recorded during the 5-year follow-up.

Radiographic Findings

The overall mean of marginal bone alteration in the anterior maxilla, appeared to be more at the control side augmented by block bone at baseline, after 1 and 5 years of loading.

In general, there was a tendency to higher degree of marginal alteration during the first year of loading, compared with the examinations after 5 years. However, the differences were not statistically significant. At the test side, the mean marginal bone levels were 1.3 ± 0.9 mm (range 0–4.0) at baseline, 2.0 ± 0.8 mm (range 0–3.7) after 1 year, and 2.0 ± 1.0 mm (range 0–4.5) after 5 years (Figure 3).

At the control side, the mean marginal bone level were 1.6 ± 1.0 mm (range 0–3.7) at baseline, 2.1 ± 1.1 mm (range 0–4.1) after 1 year, and 2.3 ± 1.0 mm (range 0–5.0) after 5 years.

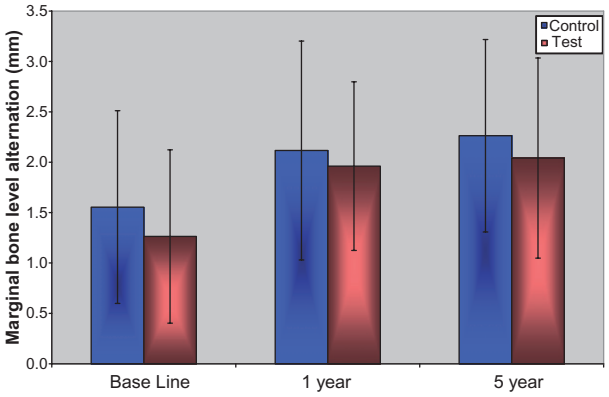

Figure 3 Marginal bone-level alteration at baseline and after 1 and 5 years of loading.

RFA Findings

The RFA are presented in Figure 4. There were no statistically significant differences between the test and control groups.

DISCUSSION

The present follow-up investigation was intended to compare the degree of marginal bone alteration in particulate bone versus block bone, placed as lateral onlay graft in the resorbed maxilla.

Several publications have reported about different augmentation techniques using autogenous bone graft as block bones as well as particulate bone.[19–23] Although bone blocks are usually used for onlays by many clinicians and particulate bone as inlays or as space fillers, the difference of the extent of marginal bone-level alternation between these two techniques has not yet been verified. On the one hand, it is believed that blocks of bone are more structurally stable and therefore less prone to

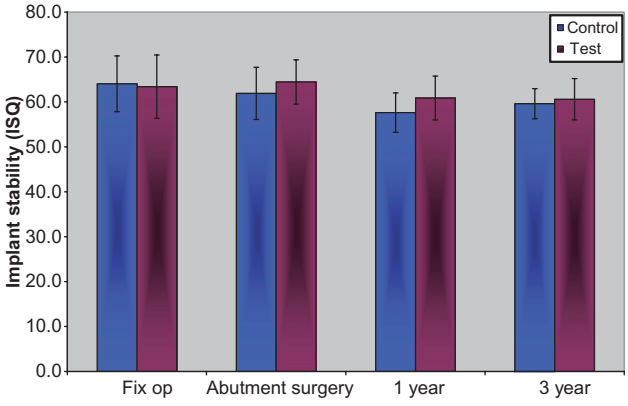

Figure 4 Resonance frequency analysis.

resorb, but on the other hand the revascularization process takes longer time compared with a mix of blood and bone particles. In order for the revascularization process to occur, an autogenous block bone undergoes a series of changes. First, the graft is subjected to an inflammatory reaction, which over a time period of a few weeks alters to a granulation phase. Then, osteoclastic activity starts, which cuts canals into the bone through which vessels and osteoblasts will follow and thereby laying down new lamellar bone (cutting and filling cones). During the following months, this bone gradually calcifies but it takes about a year for it to reach its normal physical strength.[24]

There was a tendency of less resorption on the particulate side initially, at least using this protocol where the bone particulates were mixed with the platelet concentrate. However, the sample size is limited and there were dropouts over the study period. Platelet-rich plasma can probably not protect the graft from resorption by itself; however. it makes the handling of the graft easier because it has a gluing effect between the bone particles.

Thor and colleagues[16] found only additive effects of PRP in the very early healing phase and, therefore, it is hardly an issue at all in a 5-year follow-up.

Particulate graft can be cortical or cancellous or a mix of both. According to Johansson and colleagues,[24] particulate bone has often been seen as synonymous with cancellous bone, which is misleading, because the particulate bone grafted for maxillofacial purposes is often harvested from the mandible, a bone that is cortical and dense in high degree, whereas cancellous bone has less density. Moreover, the revascularization differs between cortical and cancellous bone grafts.[25] Cortical bone is densely packed while cancellous bone is porous with marrow tissue between the bone trabeculae where the vascular ingrowth occurs more rapidly. The revascularization is completed after 2 months in cortical bone grafts and after a few weeks in cancellous bone grafts.[26]

The result of this study, which does not show any significant differences in marginal bone alteration between particulate and block bone, could be because of the fact that these two forms of grafts must undergo the same resorption and revascularization process. Our results show that particulate bone grafts harvested from a corticocancellous donor site (Iliac crest) does not accelerate the revascularization process nor resorb to a larger extent compared with cortical block bone.

Our result also shows that most of the marginal bone resorption occurs during the first year of loading, whereas the radiological measurements after 5 years of loading, only revealed limited additional resorption. In a study conducted by Nyström and colleagues,[27] the height and width of horseshoe-shaped iliac bone grafts were examined by computer tomography after 3 weeks, and 3, 6, 12, and 24 months postoperatively. The results showed a significant height reduction after 3 weeks. However, it was also observed that the main reduction in height occurred mainly between the 3-month and the 1-year examinations. This observation is in accordance to our results that the main marginal bone-level alteration occurs during the first year of loading. In a follow-up clinical report, Widmark and colleagues[28] evaluated the long-term outcome of 43 patients with severely resorbed maxillae. The difference in marginal bone loss between the graft and nongraft group did not differ significantly. It was on average 0.6 mm from prosthesis connection up to 1-year follow-up and a further 0.3 mm in the graft group and 0.5 mm in the nongraft group between the 1-year and 3-year radiographic examination after prosthesis placement. It was also concluded that the failure rate of implants is higher in patients with severely resorbed maxillae than in routine treatment of patients with adequate-residual bone volume.[17,29,30]

Widmark and colleagues[28] also stated that practically all implant losses occurred during the first 2 years. In another study conducted by Reinert and colleagues,[31] computed tomograms showed an initial vertical bone resorption of 7% during the first year after grafting including surgical contouring before insertion of implants. In agreement with Nyström and colleagues,[32] they found only minimal bone loss after 12 months. This observations regarding implant losses could be in accordance with our findings that a significantly higher degree of marginal alteration occurred during the first year of loading, compared with the examinations after 5 years.

The stability of dental implants both at placement and during function is an important criterion for the success of dental implants. Quantitative methods, including RFA, can yield valuable information.[33] The aim of the RFA was to investigate if there was any difference in implant stability between implants placed in particulate versus block bone grafts over a period of 3 years from fixture operation. Rasmusson and

colleagues[34] showed in a clinical study that there was no difference in implant stability when comparing different grafting techniques and also in this study, the RFA measurements revealed no statistically significant differences between test and control sites.

CONCLUSION

The present follow-up study showed that there is no significant difference in the extent of resorption between block bone grafts or particulate bone grafts over a 5-year period. It was also shown that most of the marginal bone alteration took place during the initial healing and first year of loading.

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