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Onlay Bone Graft Augmentation for the Treatment of Maxillary Atrophy

Long-Term (Up to 131 Months) Follow-Up on 272 Implants

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Learning Objectives

After reading this article, the participant should be able to:

1. Review the long-term survival rate of dental implants placed in areas augmented by autologous onlay bone grafts.
2. Understand the advantages of autologous bone grafts.
3. Describe techniques used for autologous bone grafts and patient preparation both pre- and postoperatively.

Abstract

Objective: The aim of the present retrospective study was to evaluate the long-term survival rate of dental implants placed in autologous onlay bone block graft (AOBG) augmentation areas, harvested from intraoral origin, used for reconstruction of maxillary atrophy.

Patients and methods: A retrospective study was conducted on 108 patients, who received a total of 272 dental implants placed in 109 maxillary augmentation sites using AOBG in combination with platelet-rich plasma (PRP) and bovine bone substitute material, covered with platelet-poor plasma (PPP).

Results: Of the 109 OBGs performed from 2000 to 2010, 108 (99.1%) were deemed "successful." Of the total implants, the great majority (94.5%) was deemed to have survived. The total implants' 10-year cumulative survival rate was 89%, compared to 99% in the anterior maxillary area.

Conclusions: We suggest that reconstruction of maxillary atrophy, through horizontal and vertical intraoral AOBG, in combination with bovine bone substitute material and PRP and covered by PPP, should be considered a reliable, safe, and very effective method to obtain a high rate of bone graft survival following a high rate of long-term implant survival.

Key Words: intraoral onlay bone graft, bone augmentation, implants, PRP, PPP, maxillary atrophy, autologous bone block

Introduction

Autologous Bone Grafting Material

Many surgical procedures have been described and used to reconstruct the atrophic edentulous maxilla in preparation for placement of implants in the desired position for fixed implant-supported restorations. Achieving an esthetic and functional implant-supported restoration in the maxillary anterior segment can be challenging, especially when severe atrophy exists. Inadequate alveolar ridge width and height frequently hampers dental implant placement or trajectory, influencing the esthetic outcome.

The reconstruction of atrophic alveolar ridges using autologous bone graft material was originally reported in 1975.¹ It is still considered the “gold standard” in bone-grafting material as it combines all the required properties: osteoinduction (bone morphogenetic proteins and other growth factors), osteogenesis (osteoprogenitor cells), and osteoconduction (scaffold).²⁻⁵

Possible Donor Sites

Possible donor sites for autologous bone grafts include extraoral sources such as the calvaria, tibia, and the iliac crest.⁶ However, intraoral sources such as the mandibular symphysis^{7,8} and ramus^{9,10} are more readily available and cause no cutaneous scarring, minimal discomfort, and less morbidity compared with the extraoral sources. The mandible, a preferable donor site, has advantages including good bone quality, convenient surgical access, minimal volume loss, good incorporation with a short healing time, high biocompatibility, and embryological proximity.¹¹

The anatomic configuration in the atrophic site influences the surgical choices (e.g., when surgical reconstruction is performed in the posterior atrophic maxilla, the standard of care would be to perform a sinus augmentation procedure for vertical augmentation, with additional vertical and/or horizontal autologous onlay bone graft augmentation if necessary).¹²⁻¹⁴ The implants would be performed simultaneously (in the case of autologous onlay bone block grafts [AOBG] horizontal augmentation) or as a second procedure. The reconstruction of the posterior maxilla prior to or at the time of implant placement by means of a sinus elevation lateral approach is considered a safe and effective procedure.¹²⁻¹⁴ The use of vertical augmentation through a combination of sinus elevation procedures and AOBG with bone blocks harvested from the mandibular symphysis or ramus has been described previously.¹² It was demonstrated that this procedure had good predictability for reconstruction of extensive atrophic ridges, with low complication and failure rates.¹² Furthermore, recent studies described exten-

sive bone deficiency reconstruction using solely intraoral block bone grafts by means of a multitier technique,¹⁵ possibly by reharvesting bone from the same donor site following its augmentation with bone replacement material in the first procedure.¹⁶

PRP and PPP

Anterior maxillary implantation is a challenging procedure for both the surgeon and prosthodontist because of the high esthetic demands for this area. Because this location is the most traumatized and exposed to habits,¹⁷⁻¹⁹ prompt and appropriate management is necessary to significantly improve the prognosis for many of the dentoalveolar injuries, especially in young patients.²⁰

Growth factors (GFs) are expressed during different phases of tissue healing and therefore are key elements in promoting tissue regeneration.²¹ The use of platelet-rich plasma (PRP) as a source of GFs has been presented by Marx and colleagues.^{22,23} PRP is an inexpensive way to obtain many GFs in physiological proportion and consequently has gained wide interest as a therapy for both soft and hard tissue injuries.²³⁻²⁵ However, there is some controversy in the literature regarding the effectiveness of PRP in the bone regeneration process, which might be due to differing protocols and equipment for obtaining PRP (centrifugation) and the low numbers of systematic studies carried out to date.²⁶ In the present study, all patients were treated with PRP combined with bovine bone substitutes as a part of the bone graft procedure protocol.

Platelet-poor plasma (PPP) is the upper layer of plasma, which is formed after centrifugation of whole blood and is composed of acellular plasma containing fibrinogen and growth factors.²⁷ In the current study, PPP was used as a biological membrane to cover the entire augmented area and donor sites to facilitate the healing and angiogenesis process. The benefits of PPP are probably due to elevated levels of fibrinogen, which has the ability to form a fibrin-rich clot once activated.²⁸ The clot within injured space provides a provisional matrix for cell migration.^{29,30}

Patient satisfaction is a key factor in the success of implant therapy, especially in the anterior maxilla. Any unfavorable relationship between the residual ridge and gingival papilla often compromises the final result. Defects in the gingival continuity or shape cannot always be compensated for by the quality of the dental restoration only.³¹ The challenge is that hard and soft tissue augmentation is necessary to achieve a successful result.³² Patient esthetics can be improved by surgical reconstruction of interdental papilla using a subepithelial connective tissue graft (SECT graft). The SECT graft was first described in 1974.³³ This procedure has several advantages over the conventional gingival graft, including excellent predictability, good gingival contour, and minimal postoperative bleeding and discomfort.³⁴ The graft procedure is carried out before or at the time of the bone augmentation procedure; or at the time of implant placement, as was done in this study.

The aim of the present retrospective study was to evaluate the effectiveness and safety of maxillary bone augmentation with intraoral origin AOBG, combined with bovine bone substitute material (Bio-Oss, Geistlich Pharma AG; Wolhusen, Switzerland) saturated with PRP and covered by PPP, to obtain a high rate of bone graft survival, followed by a high rate of long-term implant survival.

Patients and Methods

Study Population

A consecutive retrospective study was conducted from 2000 to 2010 on 108 patients (mean age at AOBG surgery was 44.5 ± 16.4 years; 74 females), who received a total of 272 dental implants placed in onlay bone graft sites for reconstruction of maxillary atrophy. A total of 109 augmentations were harvested solely from intraoral sources. Patients who were smoking at the time of the surgery were defined as “smokers” (25 [23.1%]). All the augmentations and implant placement procedures were performed by a single surgeon (DSA) as described herein. Data collected from the files included medical history and smoking habits, with special attention to conditions that might affect bone and wound healing (e.g., diabetes, osteoporosis), as well as information regarding the areas of surgery, donor sites, implant locations and characteristics, bone graft survival, and complications. AOBG was defined as “successful” in the absence of exposed bone graft/sequestrum or exposed bone fixation screw head. Follow-up time was up to 131 months (43.6 ± 32.5 months). “Implant survival” was defined as still functioning at the end of the follow-up period. Implants were evaluated by panoramic x-ray as described herein.

Inclusion and Exclusion Criteria

Patients’ inclusion criterion was the presence of atrophic edentulous areas in the maxilla with a degree of atrophy enabling implant placement in a desired esthetic position.

Patients’ exclusion criteria were as follows:

- severe kidney and/or liver disease
- congenital or acquired immunodeficiency
- ongoing chemotherapy at the time of first examination
- sequelae of radiotherapy in the head and neck area
- connective tissue disease of any kind
- poor oral hygiene
- noncompliance.

Imaging and Documentation

Preoperatively, panoramic radiography and conventional or computerized tomography (CT) scans were performed to visualize the region of interest. Immediately after the surgical intervention only panoramic radiography was performed. Five months after the bone graft surgery and before the second tier and/or the implant placement the patients were examined based upon clinical symptoms, panoramic radiography, and CT. Prior to exposure of the implant the panoramic ra-

diography was performed again. Thereafter, panoramic radiography was performed annually up to five years, then every two years.

Documentation for all clinical cases included the following:

- intraoral photographs of the initial clinical situation
- panoramic radiograph and a complete series of periapical radiographs for partially edentulous patients
- preoperative CT scans.

PRP and PPP Preparation

The preparation of PRP and PPP was done using Harvest SmartPrep processing techniques (Harvest Technology; Plymouth, MA). Briefly, 20 or 60 ml of blood was drawn from each patient using a sterile syringe containing 2 or 5 ml of anticoagulant (ACD-A). The blood was then separated into PRP with PPP (lower and upper layer) and red blood cells using a sterile chamber containing 1 or 3 ml of ACD-A and centrifuged following manufacturing instructions. The PRP was dropped into a sterile surgical cup using a sterile syringe with blunt needle. To create the PRP plus scaffold material, the Bio-Oss was saturated with PRP (**Fig 1a**). The calcium chloride (CaCl, Omrix Biopharmaceuticals; Tel Aviv, Israel) and thrombin mixture was added to form a gel with internalized Bio-Oss particles that were used as a filling material in both the recipient (filling any gaps between the recipient bed and block grafts) and the donor site. The upper layer of plasma (PPP) was gently transferred into a sterile cup using a sterile syringe with blunt needle. To create a membrane-like gel the PPP was activated by adding a mix of the human thrombin and CaCl (**Fig 1b**). PRP and PPP preparation techniques were not modified during the course of the study.

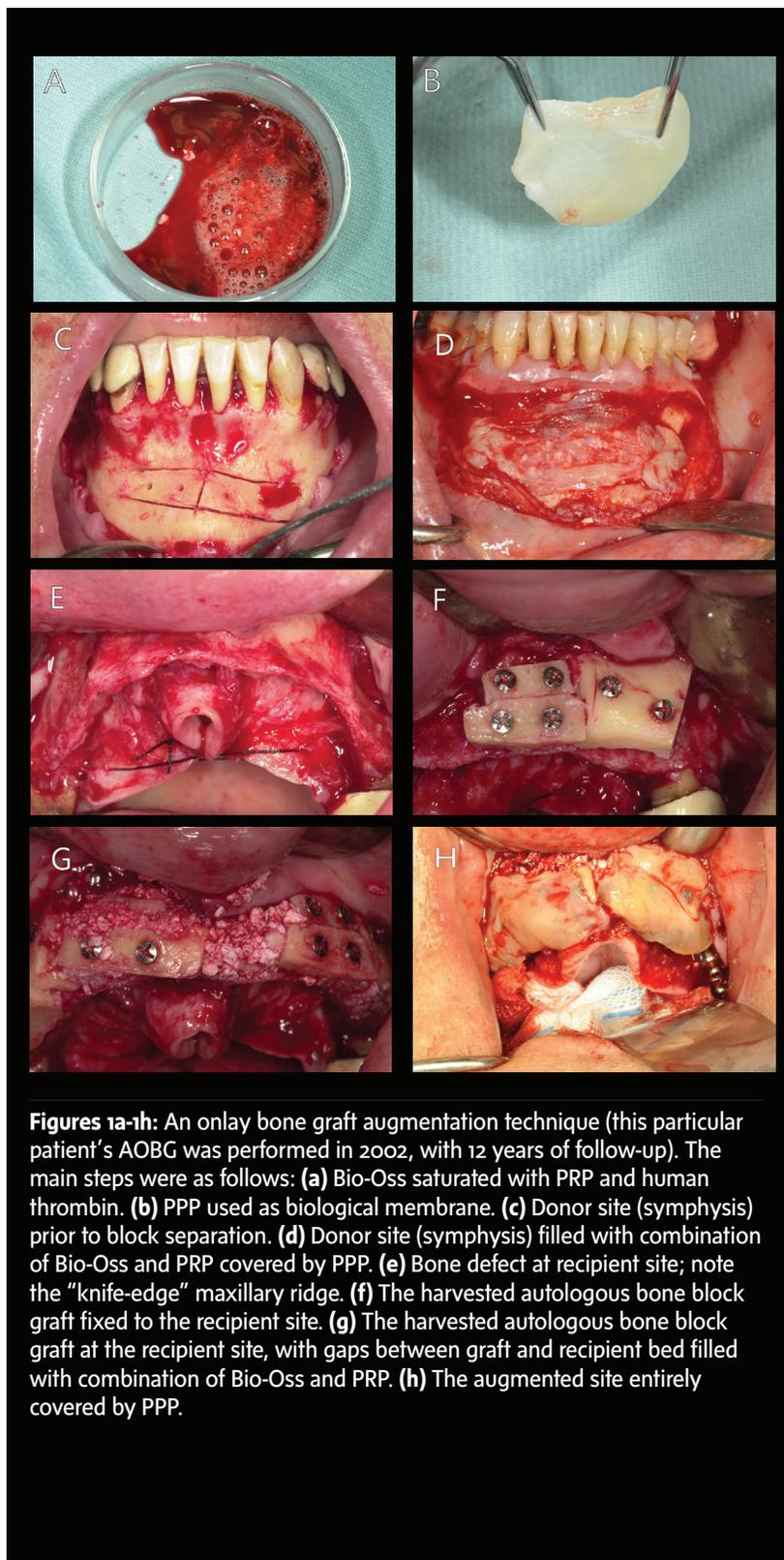
Surgical Procedures

Premedication was administered as described below. The surgery was done under general anesthesia. A midcrestal incision was made along the recipient area. A mucoperiosteal flap was reflected. The recipient site was decorticated and recontoured using a round bone bur (Aesculap AG; Tuttlingen, Germany) for better adaptation of the graft and to improve graft-to-recipient bone contact. Bone blocks were harvested from intraoral donor sites (e.g., the mandibular ramus or/and symphysis) (**Fig 1c**). The ramus area was accessed using an extension of the commonly used envelope flap for third molar extraction. The incision was made in the buccal vestibule, medial to the external oblique ridge and extended anteriorly and laterally to the retromolar pad, continuing anteriorly into the buccal sulcus of the second molar. A mucoperiosteal flap was reflected, exposing the lateral aspect of the ramus and third molar area. A reciprocating or oscillating saw (Piezosurgery device, Mectron Medical Technology, Mectron s.p.a.; Carasco GE, Italy) was used to cut through the cortex along the anterior border of the ramus. An anterior vertical cut was made in the mandibular body (the length depended upon the size of the graft needed), and a posterior vertical cut was made on the lateral aspect of the ramus. No inferior osteotomy was performed. The border cuts were made only to the depth where bleeding occurred from the underlying cancellous bone to prevent injury to the underlying neurovascular bundle. A thin chisel was gently tapped along the entire length of the oste-

otomy, taking care to avoid injury to the inferior alveolar nerve by preventing the cancellous bone from penetrating beneath the cortical layer. Graft splitting from the ramus was then completed. For the symphysis, an intrasulcular incision and two vertical releasing incisions were made posterior to the second premolar regions, reflecting the mucoperiosteal flap at the facial side.

After exposing the symphysis and locating the mental foramina, the Piezosurgery device was used to outline a rectangle the size of the exposed defect. The superior aspect of the rectangle was at least 3 to 5 mm below the tooth apices, and the integrity of the lower border of the mandible was maintained medially to the mental foramina. Osteotomes were used to free the block graft and harvest cancellous bone. In selected cases, a vestibular incision was performed; no vertical incisions were needed and the free gingival line of the lower teeth was unharmed.

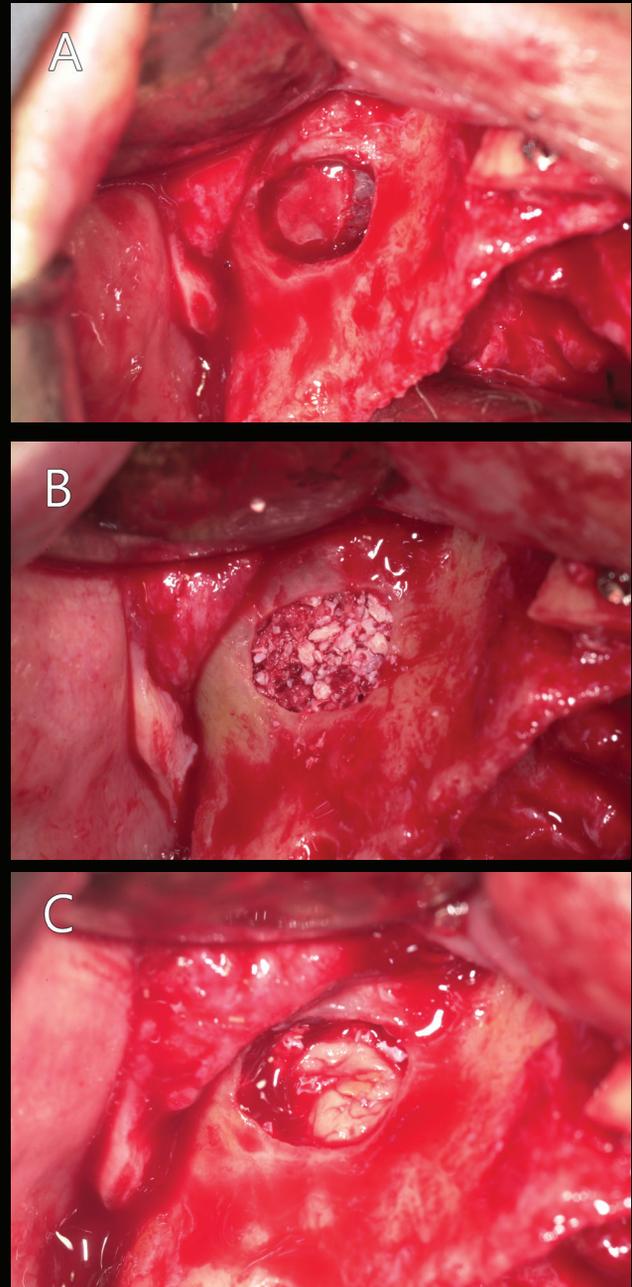
The bone blocks were restored in a sterile cold sodium chloride 0.9% solution (Teva Medical; Ashdod, Israel) for a minimal time before being fixed in the recipient site. The block graft was positioned over the recipient site in a vertical dimension (i.e., “saddle” augmentation) and/or horizontal dimension (i.e., “veneer” augmentation) with the endosteal side of the graft facing the cortical bone. To ensure immobilization, the grafts were fixed to the recipient site using 1.6-mm diameter titanium self-tap screws (KLS Martin LP; Jacksonville, FL), to be removed during implant placement (Figs 1e & 1f). Any sharp angles in the block segment that could perforate the overlying flap were eliminated, leaving a smooth outline. Corticocancellous particles and Bio-Oss saturated with PRP were used to fill the gap between the graft and recipient bed site (Fig 1g). PPP was used to cover the entire augmented area (Fig 1h). The periosteum at the base of the facial flap in the recipient site was carefully incised to allow stretching of the mucosa and tension-free adaptation of the wound margins. The flap was sutured (4-0 fast polyglactin IntroV rapide, Intromedix; Netanya, Israel) and removed two weeks later. Treatment of the donor site was completed only at the end of the procedure, after the fixation of the bone graft and the suturing of the recipient site. The donor defect was filled with Bio-Oss saturated with PRP, covered with PPP and, in some cases, with resorbable membrane (Bio-Gide, Geistlich Pharma), and sutured with the same sutures (Fig 1d).



Figures 1a-1h: An onlay bone graft augmentation technique (this particular patient’s AOBG was performed in 2002, with 12 years of follow-up). The main steps were as follows: **(a)** Bio-Oss saturated with PRP and human thrombin. **(b)** PPP used as biological membrane. **(c)** Donor site (symphysis) prior to block separation. **(d)** Donor site (symphysis) filled with combination of Bio-Oss and PRP covered by PPP. **(e)** Bone defect at recipient site; note the “knife-edge” maxillary ridge. **(f)** The harvested autologous bone block graft fixed to the recipient site. **(g)** The harvested autologous bone block graft at the recipient site, with gaps between graft and recipient bed filled with combination of Bio-Oss and PRP. **(h)** The augmented site entirely covered by PPP.

The maxillary alveolar ridge dimension criteria for intraoral onlay bone augmentation were maxillary alveolar ridge dimensions of less than 5 mm width and 10 mm height. The intraoral donor sites for harvesting autologous bone block included the mandibular ramus (78.9%), symphysis (17.4%), combination of both (1.85%), or the sinus window (1.85%). Most augmentations (78.9%) were horizontal ("veneer" type), 11% were vertical ("saddle" type), and 10.1% were a combination (two dimensions, horizontal and vertical). Out of 44 sinus augmentations, 27 were performed simultaneously with horizontal augmentation, 7 with vertical and 6 with combined (vertical and horizontal) augmentation. The marginal bone level was measured on panoramic radiographs using the implant threads as an internal standard, a technique suggested by Haas and colleagues.³⁵ The number of threads unsupported with bone at implant exposure was subtracted from the number of threads unsupported with bone at the most recent follow-up and the total multiplied by the implant pitch (in millimeters) to determine the amount of bone loss (in millimeters). The accuracy level of this method is half a pitch (0.35 to 0.375 mm) of the implant's thread. The number of threads was converted to millimeters using the millimeter-per-thread for that particular implant (one pitch 0.7 to 0.75 mm according to the manufacturer). Total bone resorption measured following implant placement that was greater than 1.5 mm (more than half a pitch/year, mean follow-up time 43.6 ± 32.5 months) was defined as a marginal bone loss.

In cases of severe posterior maxillary atrophy, 44 sinus augmentation procedures were performed via a lateral wall approach, for additional vertical augmentation (Fig 2a). Onlay bone grafting was performed simultaneously with sinus augmentation, for further vertical or/and horizontal augmentation. In cases of Schneiderian membrane perforation, an overlapping PPP or collagen resorbable membrane (Bio-Gide) was used to repair the perforation. Bio-Oss saturated with PRP was condensed into the compartment (Fig 2b). The fenestrated lateral wall of the maxillary sinus was covered with PPP, after which the mucoperiosteal flap was repositioned and saturated with a 3-0 Vicryl suture (Johnson & Johnson/Ethicon; Somerville, NJ) (Fig 2c).



Figures 2a-2c: A maxillary sinus augmentation procedure was performed via the lateral wall approach. The main steps were as follows: (a) Preparation of the window at the sinus lateral wall; the separate window is attached to the Schneiderian membrane. (b) The compartment was filled with Bio-Oss saturated with PRP. (c) The maxillary sinus lateral wall defect was covered by PPP.

Pre- and Post-Surgical Medications

At the time of surgery, patients received intravenous prophylactic antibiotics (cefazolin 1 gr and dexamethasone 20 mg) followed by oral amoxicillin 1500 mg/day for 10 days. Intravenous metronidazole 500 mg followed by oral 1000 mg/day was added when the sinus augmentation was done as well. Dexamethasone 4 mg/day was administered for 2 additional days. For penicillin-allergic patients, clindamycin HCL (Dalacin C) 1200 mg/day for 10 days was the drug of choice. In addition, patients were prescribed nonsteroidal anti-inflammatory drugs as analgesia. Patients were instructed to rinse their mouth with chlorhexidine 0.5% for 2 minutes immediately preoperative and to continue twice daily with chlorhexidine 0.2% for 10 additional days.

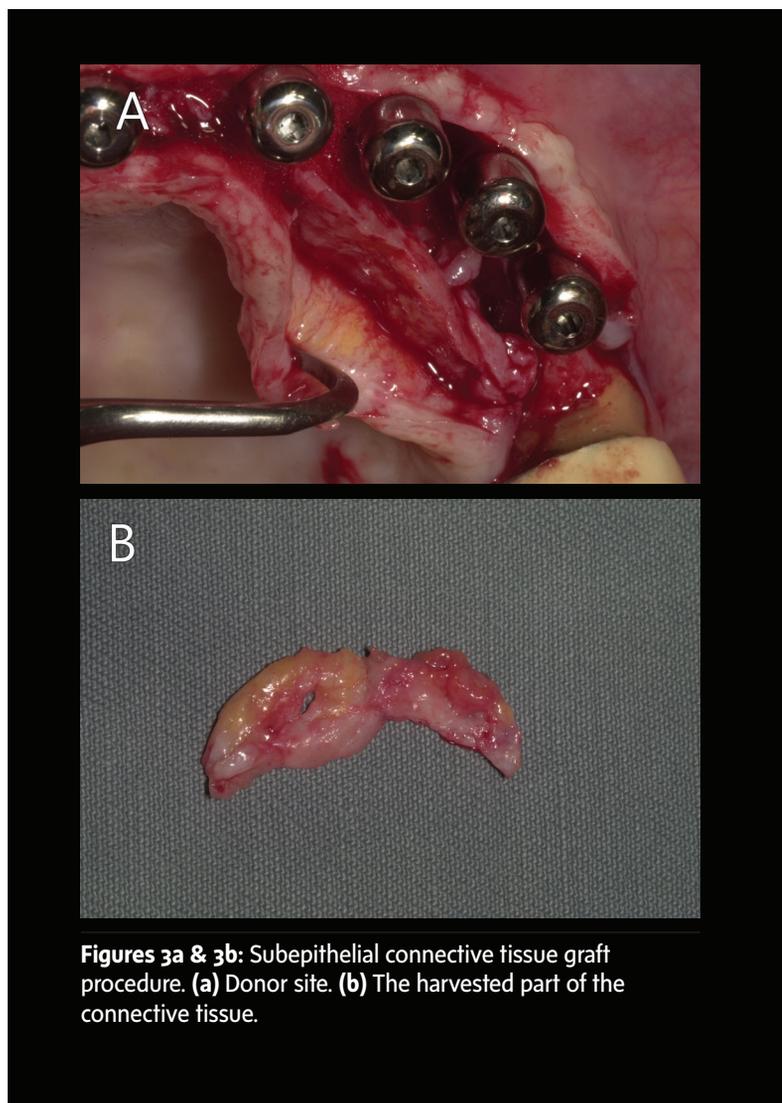
Surgical Procedure: Implant Phase

After panoramic x-ray and CT examinations, dental implant placement was performed following the AOBG augmentation (mean 4.36 ± 3.09 months). Patients were treated under local anesthesia. A total of 272 screw-type implants were placed (Screw-Vent and Spline, Zimmer Dental [Warsaw IN]; Nobel Active and Replace Select, Nobel Biocare [Yorba Linda, CA]; Implant Direct, Implant Direct LLC [Calabasas Hills, CA]). The length and diameter of the implants were selected based upon the area to be rehabilitated, the prosthetic indications, and the bone shape and volume available in each implant site.

All implants were submerged, per the primary author's augmentation and implantation protocol, in a two-stage procedure. A subepithelial connective tissue graft procedure was performed on 26 patients (7 at the time of bone augmentation procedure and 19 at the time of implant placement) and the tissue graft was harvested from the palatal donor site (Figs 3a & 3b). The healing period was 5-7 months (mean 6.5 ± 2.58), panoramic radiography was performed, and the implants were uncovered and later restored by fixed prosthesis. The implants were followed by clinical examination and panoramic radiography annually up to five years, then every two years.

Pre- and Post-Implantation Medications

One hour before implantation 1 g amoxicillin or 600 mg Dalacin C and 8 mg dexamethasone was administered. Amoxicillin (1.5 g/day) or Dalacin C (1.2 g/day) was continued for five days postoperatively. Dexamethasone (4 mg/day) was administered for two additional days.



Figures 3a & 3b: Subepithelial connective tissue graft procedure. (a) Donor site. (b) The harvested part of the connective tissue.

Statistical Analysis

Descriptive statistics analysis was performed at three levels: patient ($n=108$), only bone graft ($n=109$), and implant ($n=272$). The cumulative survival rate (CSR) was calculated by the Kaplan Meier life table analysis. To examine differences with regard to CSRs between categories of the investigated variables, the Cox proportional hazard (PH) regression model was used. The Grambsch-Therneau test was applied to ensure that the PH assumption was not violated. The models used robust standard errors (SE) that account for possible correlation between implants in the same patients. All statistical tests were two-tailed with a significant level of 0.05. Statistical analysis was performed with IBM SPSS Statistics 19 software (Chicago, IL) and R software (R Foundation for Statistical Computing, Vienna, Austria).

Results

A total of 109 AOBGs were performed, of which 108 were deemed to be successful (99.1%). In 100% of the cases the donor site was filled by Bio-Oss saturated with PRP and covered with PPP as a biological membrane. The various locations of augmentation are summarized in **Table 1**. The maxilla was divided into five areas: anterior (centrals and laterals), two middle (canines and first premolars) and two posterior (second premolar and molar area).³⁶ The rationale was that there is limited area in the anterior and posterior maxilla due to the presence of the maxillary sinus and piriform aperture versus the canine fossa area, which is normally characterized by a higher quality of residual available bone. The main site for onlay bone augmentation was the anterior maxilla (58.7%) (**Table 1**), where the ramus was the main source for the bone blocks (78.9%) (**Table 2**). Up to nine blocks were grafted per augmentation site, whereas in the majority of the cases one to three blocks were used per each site. Bio-Oss saturated with PRP was used to fill the gap between the graft and recipient bed site in 100% of augmentations. In 44 cases OBG was combined with sinus augmentation.

Most of the AOBG healing processes were uneventful (95.4%). However, a few complications were observed. The most frequent were infection, which occurred in three patients (2.8%); and bone/screw head exposure, which occurred in two patients (1.8%). Only one bone graft (0.9%) was deemed a failure due to graft exposure. In addition, a few complications in the donor sites were observed, including infection (1.8%) and lack of primary closure (1.8%). No differences in morbidity were observed using either ramus or symphysis donor sites. Treatment included a combination of irrigation with a 0.5% chlorhexidine solution and administration of oral antibiotics, according to bacterial flora examination.

The present study included 272 dental implants placed in onlay bone graft sites, 45.59% of them (124/272) in the anterior maxilla. **Figure 4** and **Table 3** present the distribution of the study implants by area and OBG direction. As can be seen, implants within the anterior area were almost exclusively inserted into a horizontal OBG (90.3%), while among implants at the posterior area, the vertical and the combined directions of augmentation were more prominent (37.1% and 21.0%, respectively). The time from the implant placement to the implant exposure differed depending upon

Table 1. Summary of Augmentation Sites

Site	Frequency	Percent
Anterior maxilla	64	58.7%
Mid-maxilla	30	27.5%
Posterior maxilla	15	13.8%
Total	109	100%

Table 2. Summary of Donor Sites

Site	Frequency	Percent
Ramus	86	78.9%
Symphysis	19	17.4%
Ramus and symphysis	2	1.85%
Sinus window	2	1.85%
Total	109	100%

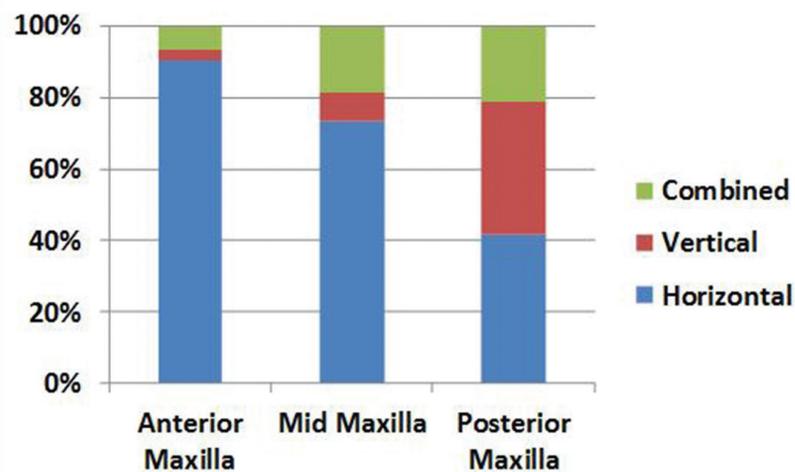


Figure 4: Implant locations according to bone graft direction.

the area; in the middle and posterior maxilla this period was longer (27.63 weeks in the middle maxilla and 28.16 weeks in the posterior maxilla compared to 23.76 weeks in the anterior). Complications after implant placement were observed in 11.8% of the total implants, with inflammation/infection (5.9%) and spontaneous premature exposed implant (3%) being the most common (Table 4). Treatment included the same protocol: a combination of irrigation with 0.5% chlorhexidine solution and oral administration of antibiotics according to bacterial flora examination. Nevertheless, total marginal bone loss of ≤ 1.5 mm accompanied by inflammation occurred in only 2.6% of the cases during the follow-up period (mean follow-up time 43.6 ± 32.5 months).

In total, 257 (94.5%) implants survived, while 5 (1.8%) implants failed at the surgical phase and another 10 (3.7%) failed at the prosthetic phase following rehabilitation, on average within four years of follow-up. Out of 15 failed implants, 5 (33.3%) occurred in smokers. Out of 257 surviving implants, 72 occurred in smokers (28%). The difference is not significant, therefore in the current study no correlation was found between implant failure and smoking. No significant correlation was found between implant failure and smoking (Table 5).

The survival rate in the first year was 96%, followed by 94% and 93% in the next two years (Fig 5). The 131 months' cumulative survival rate of the implants in the present study was 89%. The cumulative survival rate of implants according to their location shows significant difference between the implants placed at the anterior or middle parts of the maxilla as compared with those placed in the posterior areas (Table 6, Fig 6). These differences were found to be statistically significant (hazard ratio [HR]=19.43, $p < 0.03$) using Cox regression analysis (Table 7). Furthermore, implants that were placed within a two-dimensional bone graft augmentation (horizontal plus vertical) were at greater risk of failure ($p = 0.04$) compared with implants that were placed within one dimension of bone graft augmentation (horizontal or vertical) (Table 7). Table 8 focuses on the nine patients with experience of dental failure ($n = 15$), which could imply "cluster" behavior.

Table 3. Summary of Implant Locations According to the Implant Area and OBG Location

			Direction of Bone Grafting			Total
			Horizontal	Vertical	Combined	
Implant Location	Anterior maxilla	Count	112	4	8	124
		% within implant area	90.3%	3.2%	6.5%	100%
	Mid maxilla	Count	63	7	16	86
		% within implant area	73.3%	8.1%	18.6%	100%
	Posterior maxilla	Count	26	23	13	62
		% within implant area	41.9%	37.1%	21.0%	100%
Total		Count	201	34	37	272
		% within implant area	73.9%	12.5%	13.6%	100%

Table 4. Summary of Complications Following Implant Placement

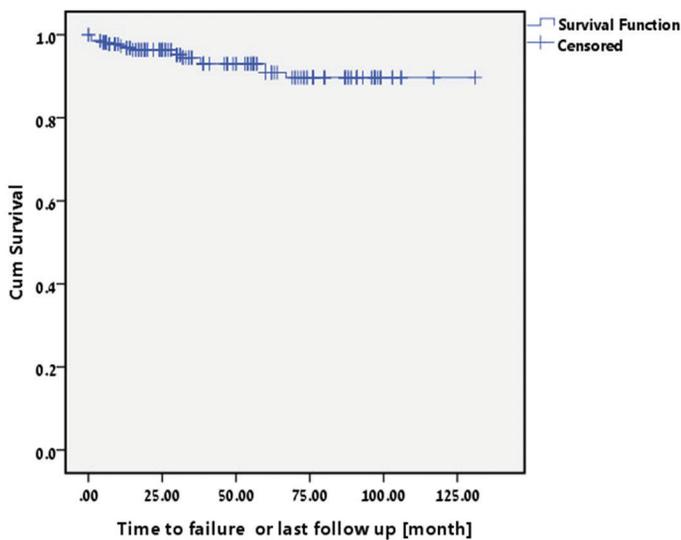
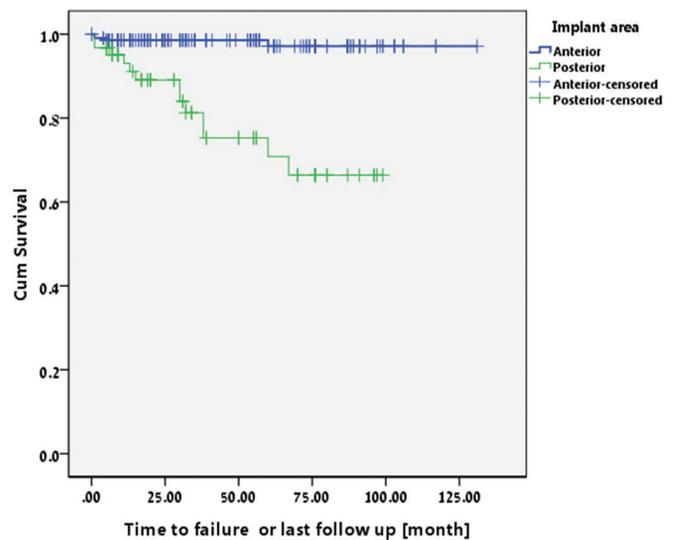
	Frequency	Percent
None	240	88.2 %
Marginal bone loss	7	2.6%
Premature Implant exposure	8	3%
Infection	16	5.9%
Infection with marginal bone loss	1	0.3%
Total	272	100%

Table 5. Correlation Between Smoking and Implant Failure

Smoking at Surgery			Implant Failure		Total
			No	Yes	
	No	Count	185	10	195
		% within implant failure	72%	66.6%	71.7%
	Yes	Count	72	5	77
		% within implant failure	28%	33.3%	28.3%
Total		Count	257	15	272
		% within implant failure	100%	100%	100%

Table 6. Cumulative Implant Survival Rates by Location

Anterior (%)	Middle (%)	Posterior (%)	Follow-up (months)
99	97	89	12
99	97	81	24
99	94	65	60
99	94	65	84
99	94	-	108
-	94	-	131

**Figure 5:** Cumulative survival rate of implants, up to 131 months' follow-up.**Figure 6:** Cumulative survival rates of implants by location.**Table 7.** Relationship Between Implant Location, Graft, Dimension, and Implant Failures

Variable	β	Robust SE	HR	P Value**
Mid Maxilla*	1.14	1.12	3.14	0.31
Posterior Maxilla*	2.97	1.05	19.43	<0.01
Graft Dimension (two)	0.97	0.48	2.65	0.04

* Compared to anterior maxilla

** Based on Cox proportional hazard model accounting for intraclass correlation

Table 8. Summary of Implant Failures

Implant Status	OBG Status	Description	Direction	Area	Smoking Status	Gender/Age
Failed (prosthetic phase)	Successful	Malocclusion with the opposite teeth	Horizontal	Posterior maxilla (#26)	Non smoker	Female 58
Failed (surgery phase)	Successful	Severe maxillary atrophy OBG combined with sinus augmentation	Vertical	Anterior maxilla (#11)	Smoker	Female 57
Failed (prosthetic phase)	Successful	Marginal bone loss	Combined	Middle, Posterior maxilla (#24,25,26)	Non smoker	Male 69
Failed (surgery phase)	Successful	Infection shortly after implantation	Horizontal	Middle maxilla (#23)	Non smoker	Female 68
Failed (prosthetic phase)	Successful	OBG combined with sinus augmentation Marginal bone loss	Horizontal	Posterior maxilla (#15,16)	Smoker	Female 54
Failed (prosthetic phase)	Successful	Marginal bone loss	Combined	Posterior maxilla (#25,26,27)	Non smoker	Male 62
Failed (prosthetic phase)	Successful	Marginal bone loss	Vertical	Posterior maxilla (#27)	Non smoker	Female 66
Failed (surgery phase)	Successful	OBG combined with sinus augmentation	Vertical	Posterior maxilla (#16)	Non smoker	Female 56
Failed (surgery phase)	Successful	OBG combined with sinus augmentation	Combined	Middle Posterior maxilla (#23,26)	Smoker	Male 49

“ The mandible, a preferable donor site, has advantages including good bone quality, convenient surgical access, minimal volume loss, good incorporation with a short healing time, high biocompatibility, and embryological proximity. ”

Discussion

Challenges

The rehabilitation of the atrophic edentulous maxilla presents a challenge because of the resorption patterns that occur after tooth loss. Moreover, for many dental practitioners, the edentulous maxilla is considered a clinical challenge during dental implant treatment. This is because insufficient bone quality, deficient alveolar ridge, undercuts, and sinus pneumatization are often encountered after tooth loss. Various hard tissue augmentation procedures have been described to enhance the height and width of the alveolar ridge, including sinus, subnasal, and bone augmentations.^{12,14} The use of autologous transplants from varying donor sites is a preferred method due to their osteoinductive and osteogenous properties.^{37,38} After extensive reconstruction of the atrophic maxilla with bone grafts and dental implants, long-term stability and good esthetic outcome are desirable.

The purpose of the present retrospective study was to evaluate the long-term survival rate of dental implants placed in intraoral origin autologous onlay bone grafts in cases of maxillary atrophy.

Survival Rates in the Literature

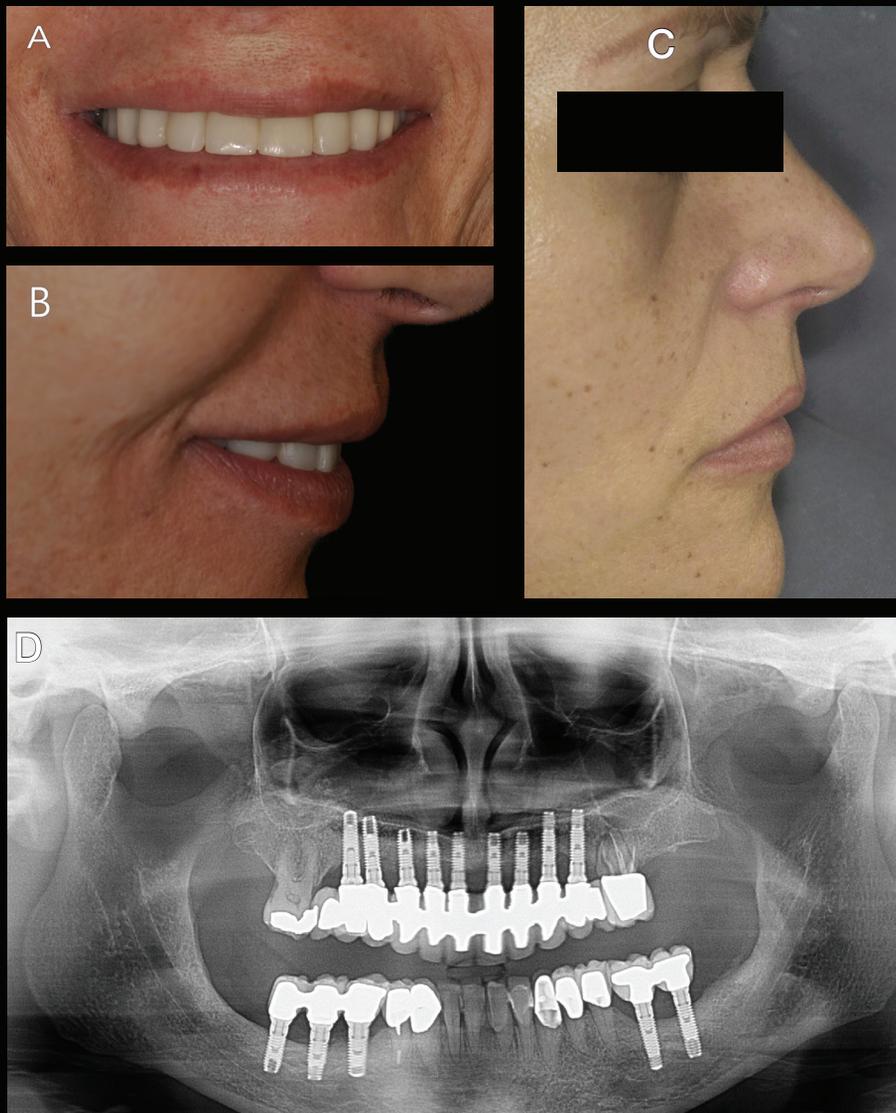
In the literature the survival rate of implants placed in the augmented sites ranged from 76.8% to 100%, with the majority of studies indicating more than 90% survival after at least one year of function.^{3,4} The reported mean survival rate of implants placed in reconstructed maxillae with a staged approach varied between 80% and 100% due to different types of defects and surgical approaches.³⁹⁻⁴¹ Moreover, the meta-analysis of 29 publications demonstrated that the majority of implant failures occurred in patients reconstructed with iliac grafts (failure rate 17.5%).³⁹ The failure rate for implants placed in calvarial grafts was 5.1% and that for implants placed in intraoral grafts was 2.9%, clearly demonstrating the highest success rate for the implants placed in intraoral bone grafts. In this study the high long-term survival rate (94.5%) of dental implants placed in areas of maxillary atrophy lends further support to the effectiveness and predictability of utilizing bone grafts of intraoral origin to support dental implantation.

Healing

The course of healing after autologous bone transplantation has been well-researched and described.^{42,43} First, resorptive processes dominate in the context of inflammation followed by a healing process that includes graft vascularization and penetration of the proliferative cells to the transplanted bone. Finally, the transplanted bone will be resorbed and replaced successively with new bone.^{42,43} In the current study all augmentations at donor and augmented sites (in addition to bone grafts or bone supplements) were saturated with PRP as a source of essential growth factors, after being covered with PPP to facilitate the healing and angiogenesis. It has been shown that PRP in combination with bovine bone substitutes manifests a positive effect on bone formation.^{44,45} Several studies have reported that use of autologous bone in combination with PRP improves bone implant integration.^{23,46-48} We suggest that PRP stimulates the healing process of the grafted bone by local delivery of growth factors that could promote the healing process and eventually prevent resorption. In fact, in this study we have demonstrated a low rate of the marginal bone loss (2.6%) following implant placement.

Most of the augmentations were horizontal located in the anterior maxilla when it was done for two purposes: to support the dental implants and to support the soft facial tissue. This resulted in 100% success of AOBG with only a few complications and various positive esthetic outcomes, demonstrating the effectiveness and safety of this technique (Figs 7a-7d), especially in the anterior maxilla (Figs 8a-8t). The long-term OBG and implant survival (12 years' follow-up) (Figs 7a-7d), together with a good esthetic outcome, strongly supports the high efficacy of the described AOBG technique. It should be noted that we did not check the esthetic outcome using objective parameters. However, positive esthetic results as a consequence of the soft tissue support were obvious (Figs 8n-8t). Vertical and two-dimensional augmentations were done mainly in the posterior maxilla due to severe atrophy and enlarged intermaxillary distance and pattern of maxillary resorption.⁴⁹

“ Anterior maxillary implantation is a challenging procedure for both the surgeon and prosthodontist because of the high esthetic demands for this area. ”



Figures 7a-7d: Final restoration 12 years postoperative: (a-c) Notice the lips' support. (d) Panoramic view. (Prosthodontist: Dr. Sima Ophir, Tel Aviv, Israel)

Figures 8a-8f: Case study.



(a) Preoperative panoramic view, a few days after trauma to the anterior maxilla.



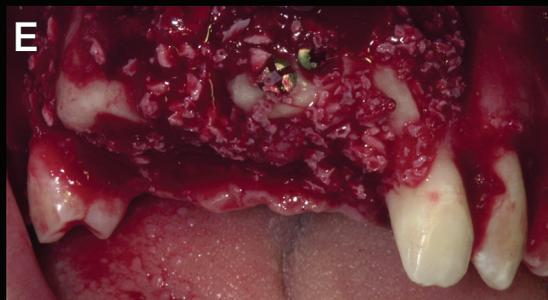
(b) CT scan of the injured area in the anterior maxilla; note the alveolar fractures in the palatal plate (yellow arrows).



(c) At the time of the first surgery, the premaxilla with the area of four missing teeth (from the right maxillary canine to the left maxillary first incisor).



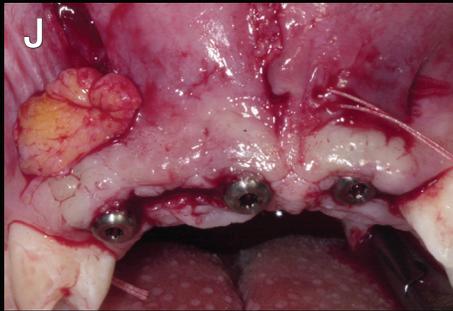
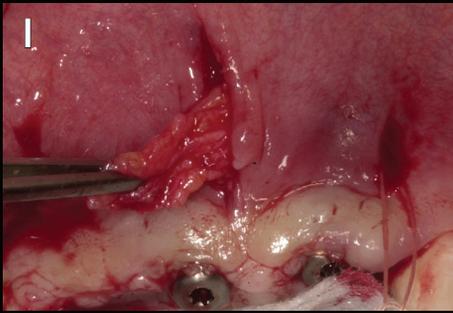
(d) Two blocks harvested from the left mandibular ramus were used for horizontal augmentation. Three implants, in the areas of missing #13, #11, and #21, were placed simultaneously at the time of augmentation.



(e, f) The gaps between the grafted blocks were filled with bone substitute saturated in PRP and covered by PPP.



(g) Panoramic view immediately postoperative.

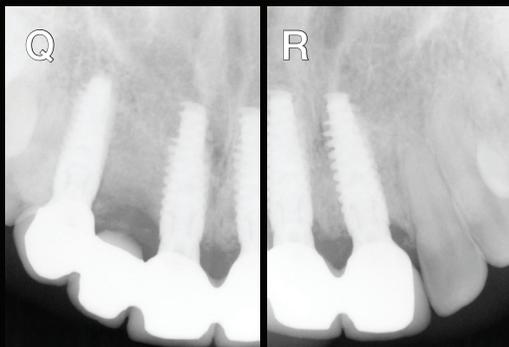


(h-k) Five months later, vertical incisions in the lining mucosa were performed for screw removal and for connective tissue grafting harvested from the palate, through a tunneling procedure. This technique of vertical incisions prevents scar tissue in the attached gingiva and does not interfere with the vertical blood supply to the gingiva. For implant exposure, small openings in the midcrestal area were made and narrow healing collars were situated.



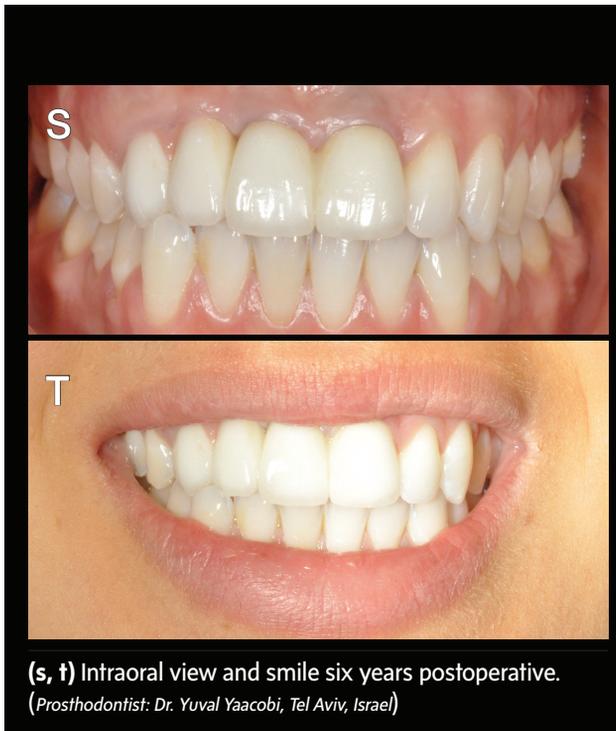
(l) Two weeks later, at the time of suture removal.

(m) Rehabilitation with #12 as a pontic and pink porcelain papilla between #12 and #13.



(n, o) Pre- and postoperative smile.

(p-r) Panoramic and periapical views six years postoperative.



(s, t) Intraoral view and smile six years postoperative.
(Prosthodontist: Dr. Yuval Yaacobi, Tel Aviv, Israel)

Causes of Failure

Causes for implant failure are multifactorial and include patient-related factors (e.g., general health status, smoking habits, oral hygiene); implant-related factors (e.g., implant architecture, surface, location); and prosthetic-related factors (e.g., occlusal forces, implant loading).^{44,50,51} In the present long-term retrospective study no significant correlation between health status and rate of implant failure was found. Although smoking has been shown to be a risk factor in OBG complications,⁵² in the present study it did not appear to be significant in promoting implant failure. Of the 15 implants that failed only 3 occurred in smokers. It should be mentioned that 15 implant failures occurred in 9 patients, which could imply "cluster" behavior. Previous literature reviews examined the finding that implant failures are not randomly distributed in the treated populations and that implant loss clusters (more than one implant failure per patient, not necessarily in the same area or quadrant) in specific high-risk groups and individuals.^{53,54} Significant differences in implant survival rates were observed between the anterior or middle versus the posterior portions of the maxilla. The higher success rate of the anterior area might be attributed to factors such as functional forces, oral hygiene, and bone quality. Furthermore, it was demonstrated that combined augmentation (horizontal and vertical) are more common in the posterior regions, which are more prone to failure as compared to a single dimension augmentation (horizontal or vertical).

Success in Implantology

The current definition of "success" in implantology is not only the long-term survival of implants but also good esthetic results that depend upon the state of soft tissues. Severe bone atrophy is always accompanied by abnormality in the gingival morphology. When soft tissue augmentation is necessary, it often is performed as a secondary surgical procedure. In this study 26 subepithelial connective tissue grafts were performed, with 7 of them performed following a first surgical procedure and 19 following implant placement.

Conclusion

Augmentation of atrophied maxilla through the positioning of horizontal and vertical autologous onlay bone grafts, following a technique that was described in this study, should be considered reliable, safe, and very effective in obtaining a high rate of bone graft success after a high rate of long-term implant survival.

References

1. Brånemark PI, Lindström J, Hallen O, Breine U, Jepsson PH, Ohman A. Reconstruction of the defective mandible. *Scand J Plast Reconstr Surg.* 1975; 9(2):116-28.
2. Misch CM. Ridge augmentation using mandibular ramus bone grafts for the placement of dental implants: presentation of a technique. *Pract Periodontics Aesthet Dent.* 1996 Mar; 8(2):127-35.
3. Nyström E, Ahlqvist J, Gunne J, Kahnberg KE. 10-year follow-up of onlay bone grafts and implants in severely resorbed maxillae. *Int J Oral Maxillofac Surg.* 2004 Apr;33(3):258-62.
4. Nyström E, Nilson H, Gunne J, Lundgren S. A 9-14 year follow-up of onlay bone grafting in the atrophic maxilla. *Int J Oral Maxillofac Surg.* 2009 Feb;38(2):111-6.
5. Dimitriou E, Jones E, McGonagle D, Giannoudis PV. Bone regeneration: current concepts and future directions. *BMC Med.* 2011 May 31;9:66.
6. Clementini M, Morlupi A, Agrestini S, Ottria L. Success rate of dental implants inserted in autologous bone graft regenerated area: a systemic review. *Oral Implantol (Rome).* 2011 Jul;4(3-4):3-10.
7. Zouhary KJ. Bone graft harvesting from distant sites: concepts and techniques. *Oral Maxillofac Surg Clin North Am.* 2010 Aug;22(3):301-16.
8. Misch CM, Misch CE, Resnik RR, Ismail YH. Reconstruction of maxillary alveolar defects with mandibular symphysis grafts for dental implants: a preliminary procedural report. *Int J Oral Maxillofac Implants.* 1992 Fall;7(3):360-6.
9. Montazem A, Valauri DV, St-Hilaire H, Buchbinder D. The mandibular symphysis as a donor site in maxillofacial bone grafting: a quantitative anatomic study. *J Oral Maxillofac Surg.* 2000 Dec;58(12):1368-71.
10. Proussaefs P, Lozada J, Kleinman A, Rohrer MD. The use of ramus autogenous block grafts for vertical alveolar ridge augmentation and implant placement: a pilot study. *Int J Oral Maxillofac Implants.* 2002 Mar-Apr;17(2):238-48.

11. Aalam AA, Nowzari H. Mandibular cortical bone grafts part 1: anatomy, healing process, and influencing factors. *Compend Contin Educ Dent*. 2007 Apr;28(4):206-12.
12. Schwartz-Arad D, Levin L. Intraoral autogenous block onlay bone grafting for extensive reconstruction of atrophic maxillary alveolar ridges. *J Periodontol*. 2005 Apr;76(4):636-41.
13. Del Fabbro M, Testori T, Francetti L, Weinstein R. Systematic review of survival rates of implants placed in the grafted maxillary sinus. *Int J Periodontics Restorative Dent*. 2004 Dec;24(6):565-77.
14. Schaudy C, Vinzenz K. Osteoplastic reconstruction of severely resorbed maxilla by stack plasty: combining sinus augmentation with lateral and vertical onlay bone grafting. *Br J Oral Maxillofac Surg*. 2014 Sep;52(7):647-51.
15. Schwartz-Arad D, Levin L. Multitier technique for bone augmentation using intraoral autogenous bone blocks. *Implant Dent*. 2007 Mar;16(1):5-12.
16. Schwartz-Arad D, Levin L. Symphysis revisited: clinical and histological evaluation of newly formed bone and reharvesting potential of previously used symphyseal donor sites for onlay bone grafting. *J Periodontol*. 2009 May;80(5):865-9.
17. Altay N, Gungor HC. A retrospective study of dentoalveolar injuries of children in Ankara, Turkey. *Dent Traumatol*. 2001 Oct;17(5):201-4.
18. Rocha MJ, Cardoso M. Traumatized permanent teeth in Brazilian children assisted at the Federal University of Santa Catarina, Brazil. *Dent Traumatol*. 2001 Dec;17(6):245-9.
19. Levin L, Friedlander LD, Geiger SB. Dental and oral trauma and mouth guard use during sport activities in Israel. *Dent Traumatol*. 2003 Oct;19(5):237-42.
20. Schwartz-Arad D, Levin L. Post-traumatic use of dental implants to rehabilitate anterior maxillary teeth. *Dent Traumatol*. 2004 Dec;20(6):344-7.
21. Lieberman JR, Daluiski A, Einhorn TA. The role of growth factors in the repair of bone. Biology and clinical applications. *J Bone Joint Surg Am*. 2002; 84-A(6):1032-44.
22. Marx RE, Carlson ER, Eichstaedt RM, Schimmele SR, Strauss JE, Georgeff KR. Platelet-rich plasma: growth factor enhancement for bone grafts. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 1998 Jun;85(6):638-46.
23. Marx RE. Platelet-rich plasma: evidence to support its use. *J Oral Maxillofac Surg*. 2004 Apr;62(4):489-96.
24. Nauth A, Giannoudis PV, Einhorn TA, Hankenson KD, Friedlaender GE, Li R, Schemitsch EH. Growth factors: beyond bone morphogenetic proteins. *J Orthop Trauma*. 2010 Sep;24(9):543-6.
25. Anitua E, Tejero R, Zalduendo MM, Orive G. Plasma rich in growth factors promotes bone tissue regeneration by stimulating proliferation, migration and autocrine secretion in primary human osteoblasts. *J Periodontol*. 2013 Aug;84(8):1180-90.
26. Gao C, Harvey EG, Chua M, Chen BP, Jian F, Liu Y, Li A, Wang H, Henderson, JE. MSC-seeded dense collagen scaffolds with a bolus dose of VEGF promote healing of large bone defects. *Eur Cell Mater*. 2013 Oct;26:195-207.
27. Del Fabbro M, Bortolin M, Taschieri S. Is autologous platelet concentrate beneficial for post-extraction socket healing? A systematic review. *Int J Oral Maxillofac Surg*. 2011 Sep;40(9):891-900.
28. Hatakeyama I, Marukawa E, Takahashi Y, Omura K. Effects of platelet-poor plasma, platelet-rich plasma, and platelet-rich fibrin on healing of extraction sockets with buccal dehiscence in dogs. *Tissue Eng Part A*. 2014 Feb;20(3-4):874-82.
29. Clark RA. Fibrin and wound healing. *Ann NY Acad Sci*. 2001;936:355-67.
30. Brown F, Lanir J, McDonagh, McDonagh J, Tognazzi K, Dvorak AM, Dvorak HF. Fibroblast migration in fibrin gel matrices. *Am J Pathol*. 1993 Jan;142(1):273-83.
31. Buser D, Martin W, Belser UC. Optimizing esthetics for implant restorations in the anterior maxilla: anatomic and surgical considerations. *Int J Oral Maxillofac Implants*. 2004;19 Suppl:43-61.
32. Elian N, Ehrlich B, Jalbout ZN, Classi AJ, Cho SC, Kamer AR, Froum S, Tarnow DP. Advanced concepts in implant dentistry: creating the "aesthetic site foundation." *Dent Clin North Am*. 2007 Apr;51(2):547-63.
33. Edel A. Clinical evaluation of free connective tissue grafts used to increase the width of keratinized gingiva. *J Clin Periodontol*. 1974 Dec;1(4):185-96.
34. Thoma DS, Buranawat B, Hämmerle CH, Held U, Jung RE. Efficacy of soft tissue augmentation around dental implants and in partially edentulous areas: a systematic review. *J Clin Periodontol*. 2014 Apr;41 Suppl 15:S77-91.
35. Haas R, Mensdorff-Pouilly N, Mailath G, Watzek G. Brånemark single tooth implants: a preliminary report of 76 implants. *J Prosthet Dent*. 1995 Mar;73(3):274-9.
36. Schwartz-Arad D, Gulayev N, Chaushu G. Immediate versus non-immediate implantation for full-arch fixed reconstruction following extraction of all residual teeth: a retrospective comparative study. *J Periodontol*. 2000 Jun;71(6):923-8.
37. Wiltfang J, Schultze-Mosgau S, Nkenke E, Thorwarth M, Neukam FW, Schlegel KA. Onlay augmentation versus sinus lift procedure in the treatment of the severely resorbed maxilla: a 5-year comparative longitudinal study. *Int J Oral Maxillofac Surg*. 2005 Dec;34(8):885-9.

38. Chiapasco M, Zaniboni M, Rimondini L. Autogenous onlay bone grafts vs. alveolar distraction osteogenesis for the correction of vertically deficient edentulous ridges: a 2–4-year prospective study on humans. *Clin Oral Implants Res.* 2007 Aug;18(4):432-40.
39. Elo JA, Herford AS, Boyne PJ. Implant success in distracted bone versus autogenous bone-grafted sites. *J Oral Implants Res.* 2009;35(4):181-4.
40. Kim JW, Cho MH, Kim SJ, Kim MR. Alveolar distraction osteogenesis versus autogenous onlay bone graft or vertical augmentation of severely atrophied alveolar ridges after 12 years of long-term follow-up. *Oral Surg Oral Med Pathol Oral Radiol.* 2013 Nov;116(5):540-9.
41. Chiapasco MI, Zaniboni M, Boisco M. Augmentation procedures for the rehabilitation of deficient edentulous ridges with oral implants. *Clin Oral Implants Res.* 2006 Oct;17 Suppl 2:136-59.
42. Burchardt H. Biology of bone transplantation. *Orthop Clin North Am.* 1987 Apr;18(2):187-96.
43. Buckwalter JA, Glimcher MJ, Cooper RR, Recker R. Bone biology. II: formation, form, modeling, remodeling, and regulation of cell function. *Instr Course Lect.* 1996;45:387-99.
44. Thor A, Wannfors K, Sennerby L, Rasmusson L. Reconstruction of the severely resorbed maxilla with autogenous bone, platelet-rich plasma, and implants: 1-year results of a controlled prospective 5-year study. *Clin Implant Dent Relat Res.* 2005;7(4):209-20.
45. Plachokova AS, Nikolidakis D, Mulder J, Jansen JA, Creugers NH. Effect of PRP on bone regeneration in dentistry: a systemic review. *Clin Oral Implants Res.* 2008 Jun;19(6):539-45.
46. Camargo PM, Lekovic V, Weinlaender M, Vasilic N, Madzarevic N, Kenney M. Platelet-rich plasma and bovine porous bone mineral combined with guided tissue regeneration in the treatment of intrabony defects in humans. *J Periodontol Res.* 2002 Aug;37(4):300-6.
47. Fennis JPM, Stoelinga PJW, Jansen JA. Mandibular reconstruction: a histological and histomorphometric study on the use of autogenous scaffolds, particulate cortico-cancellous bone grafts and platelet-rich plasma in goats. *J Oral Maxillofac Surg.* 2004 Jan;33(1):48-55.
48. Schwartz-Arad D, Levin L, Aba M. The use of platelet rich plasma (PRP) and platelet rich fibrin (PRF) extracts in dental implantology and oral surgery. *Refuat Hapeh Vehashinayim.* 2007 Jan;24(1):51-5, 84. Hebrew.
49. Watzek G. *Endosseous implants: scientific and clinical aspects.* Chicago: Quintessence Pub.; 1995. p. 40-62.
50. Montes CC, Pereira FA, Thomé G, Alves ED, Acedo RV, de Souza JR, Melo AC, Trevilatto PC. Failing factors associated with osseointegrated dental implant loss. *Implant Dent.* 2007 Dec;16(4):404-12.
51. Esposito M, Hirsch JM, Lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated oral implants. (II). Etiopathogenesis. *Eur J Oral Sci.* 1998 Jun;106(3):721-64.
52. Levin L, Herzberg R, Dolev E, Schwartz-Arad D. Smoking and complications of onlay bone grafts and sinus lift operations. *Int J Oral Maxillofac Implants.* 2004 May-Jun;19(3):369-73.
53. Jemt T, Hager P. Early complete failures of fixed implant-supported prostheses in the edentulous maxilla: a 3-year analysis of 17 consecutive cluster failure patients. *Clin Implant Dent Relat Res.* 2006;8(2):77-86.
54. Schwartz-Arad D, Laviv A, Levin L. Failure causes, timing, and cluster behavior: an 8-year study of dental implants. *Implant Dent.* 2008 Jun;17(2):200-7. **JCD**



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