A failed implant site is prone to reduced alveolar bone volume, both horizontally and vertically. The present study assessed the outcome of using cancellous bone block allografts for ridge reconstruction following the removal of failed implants associated with severe bone loss. Individuals presenting with failed implants and massive bone loss were included. Cancellous bone block allografts were used for reconstruction of the atrophic alveolar ridge. Radiographic evaluation at 6 months postgrafting revealed favorable bone healing, allowing implant placement. Bone biopsy samples were taken during implant placement. Twenty-four blocks and 58 implants were placed in 16 patients. Over a mean follow-up time of 40 ± 15 months, the mean bone gain was 5 ± 0.5 mm horizontally and 7 ± 0.5 mm vertically. Block and implant survival rates were 96% (1 block failed) and 95% (3 implants failed), respectively. Histomorphometrically, the mean percentage of newly formed bone was 40%, with 20% residual cancellous block allograft and 40% marrow and connective tissue. Cancellous bone block allograft is a viable treatment alternative for reconstructing the alveolar ridge to achieve a successful second reimplantation, even in the presence of initial severe bone loss.

The present authors previously evaluated the survival rate of implants in sites of previously failed and removed implants and evaluated factors affecting the outcomes. The survival rate was 93%, and a third implant placement in the same site yielded a survival rate of 85%; it was concluded that a previous implant failure should not discourage practitioners from a second or even a third attempt.
The knowledge that reimplantation is possible and predictable is not enough: Patient acceptance must be attained. The present authors previously explored the major factors that can affect the patient’s decision to replace failed implants. The likelihood of a patient with minor bone loss to undergo reimplantation were 20 times greater (odds ratio: 20.4) compared to a patient with severe bone loss. The main patient-related reasons for avoiding reimplantation were the additional costs (27%), fear of additional pain (17.7%), and fear of a second failure (16.2%).

The purpose of the present study is to assess the use of cancellous bone block allografts to reconstruct the atrophic alveolar ridge following the removal of failed implants with severe bone loss.

Materials and Methods

Individuals referred for treatment of failed endosseous implants with severe bone loss (> 50% of the implant diameter/height) were included in the present study (Fig 1). The study was reviewed and approved by the ethical committee of the Tel Aviv University. Reasons for implant failure were recorded. Diagnostic workup included fabrication of diagnostic casts for determining inter- and intra-arch relationships, panoramic radiographs, and CBCT scans.

The treatment plan was thoroughly explained to the patient, detailing the implant removal, a 3-month soft-tissue healing period, cancellous allograft block grafting, a 6-month waiting period, implant placement, an additional 4-month waiting period, a second-stage surgery followed by a 6-week soft tissue healing period, and the final prosthetic reconstruction. After signing a detailed informed consent, initial preparations (including scaling and root planing) were performed to provide a more favorable oral environment for wound healing.

Surgical Procedure

Implant removal was associated with massive bone loss, according to CBCT scans (Fig 2). Allogeneic block grafting was scheduled. Immediately before surgery, the patients rinsed for 1 minute with 2% chlorhexidine mouthwash (Tarodent, Taro) and were instructed to rinse twice daily for 2 weeks postsurgery.

Intrasulcular, midcrestal, and vertical incisions that extended over the mucogingival junction were made to elevate a full mucoperiosteal flap (Fig 3a). Cancellous block allograft (OraGraft, LifeNet Health; CCUBE-03, 15 × 30 × 8 mm) was fitted to the donor site morphology by continuous and gradual morphologic adaptation to the recipient site using a high-speed round bur with water irrigation. The block was fixed using lag screws (Mincro, OsteoMed; 10-mm length, 1.6-mm diameter) (Fig 3b). The fixed block was covered with freeze-dried bone allograft particles (cortical mineralized OraGraft; particle size: 250 to 1,000 µm) (Fig 3c) and a cross-linked biodegradable membrane (Ossix Plus, Datum Dental) (Fig 3d). Tension-free closure was achieved following periosteal releasing incisions (Fig 3e). Final closure was attained using horizontal mattress and simple sutures.

The patients were prescribed postsurgical antibiotics, anti-inflammatories, and chlorhexidine mouthwashes. Sutures were removed after 14 days. During the
follow-up period, the patients were examined monthly. At 6 months postgrafting, a clinical examination (Fig 4a) and CBCT scans (Fig 4b) were performed to determine whether there was abundant bone volume available for implant placement, to ensure an esthetic and stable result. The fixation screws were removed (Fig 4c), the surgical sites were prepared using standard procedures, and implants were placed (Fig 4d). Bone biopsy samples were taken during implant placement.

After a healing period of 4 months, the implants were exposed. The surgical approach used was limited through a mid-crestal incision, to allow healing cap placement and soft tissue manipulation.
Six weeks later, an implant impression was taken and the healing caps were connected. After 2 additional weeks, abutments and provisional restorations were placed using provisional cement (Temp-Bond, Kerr) to allow the peri-implant tissues to develop. Six weeks later, the final full-ceramic crowns were placed (Fig 5). Patients were satisfied with the function and esthetics of the final result. For the first year after placement of the implant-supported prosthesis, patients returned for follow-up appointments every 3 months. The protocol during recall appointments included checking for component integrity and tightness, periapical imaging of individual implants performed with a film holder (XCP ring, Dentsply Rinn), and maintaining and reinforcing hygiene measures.

**Bone Level Evaluations**

Crestal bone loss was measured at the mesial and distal implant aspects via computer analysis of periapical radiographs. Namely, periapical radiographs taken immediately after implantation were used as baseline. The last follow-up periapical radiographs available were used to assess the amount of marginal bone loss. All images were available in their actual size. For each implant included in the study, baseline and last follow-up radiographs were compared using ImageJ (National Institutes of Health). The initial crestal bone height was measured from a reference point (the implant-abutment junction) to the nearest bone-implant interface (the adjacent mesial and distal crestal bone-implant contacts). Measurements were compared with the crestal bone height on the radiograph obtained at the last follow-up, and the difference between the two measurements was defined as marginal bone loss. The length of the implant was used as a constant variable to prevent against visual vertical distortion of the radiographs.

Patients were advised to come back for yearly follow-ups in addition to dental hygiene visits every 3 months.

Bone gain was compared to the initial CBCT (prior to bone grafting) by superimposing paraxial views at the same distance from the midline. Clinical bone was measured at each stage (bone augmentation, implant placement, and implant uncovering) using a UNC 15 periodontal probe (Hu-Friedy) at the center of the implant site. Horizontal measurements were performed directly over the residual alveolar ridge. Vertical measurements were performed using two probes: One connecting the cementoenamel junction of the adjacent teeth and the second extending from the first probe to the residual alveolar ridge. All measurements were performed by two independent examiners (L.C. and S.N.) and were double-checked to allow standardization of the results.

**Histomorphometric Evaluation**

The biopsy sample specimens taken at implant placement were fixed in 10% buffered formalin for 24 hours. Specimens were embedded in paraffin and prepared for hematoxylin and eosin (h&e) staining. The
bony cores first underwent rapid decalcification via ethylenediaminetetraacetic acid (pH = 6) for 72 hours. Following decalcification, the cores were embedded in paraffin. Slides were obtained (4 µm) using a microtome (RM2235, Leica Biosystems), and the slides were stained with h&e.

Using a light microscope with a mounted digital camera, each bony core was photographed. The entire area of the cores was covered in five consecutive, nonoverlapping photomicrographs (×200 magnification), which were saved as JPEG files. A presentation was prepared in which each case, represented by five successive slides, showed the photomicrographs copied from the corresponding JPEG files of the case. A square grid (10 × 10 squares) was prepared, wherein the center of each square was marked by a plus sign (+), and this grid was superimposed on each photomicrograph in the presentation.

A histomorphometric evaluation of the photomicrographs was performed using a modified point-counting methodology. The parameters evaluated in the study were bone, residual cancellous bone–block allograft, and connective tissue. Each time one of these parameters overlapped the “+” mark, it was awarded one point. Whenever a “+” fell outside the tissue, that point was excluded from the total points counted for each photomicrograph (eg, 100 points), which allowed only the effective points for the final calculations. After all five photomicrographs were examined for each case, the sum of the points overlying each parameter was calculated and divided by the total effective points. This allowed the mean volume fraction (Vv) to be calculated for each parameter, and the results were expressed as percentages. A calculation of the percentage of the residual cancellous bone–block allograft surface covered by newly formed bone was also performed.

**Statistical Analysis**

Student t test and Pearson correlation test were used for statistical analysis of the data, calculated based on the overall percentage of each measured component in each slide.

**Results**

Twenty-four blocks and 58 implants were placed in 16 patients. The mean patient age was 55 ± 15 years (range: 22 to 80 years).

Clinically measured mean bone gain was 5 ± 0.5 mm horizontally and 7 ± 0.5 mm vertically. CBCT only measured mean horizontal bone gain, with a value of 4.5 ± 1 mm. Reasons for implant failure included peri-implant disease (50 of 58 implants) and biomechanical failure (ie, inability to use prosthetic components, and implant removal resulted in severe bone loss; 8 of 58 implants).

Of the 16 patients, the implant sites included the anterior maxilla (4 patients, 4 implants), anterior mandible (6 patients, 36 implants), and posterior mandible (6 patients, 18 implants). During implant placement, the ossified remnants of the resorbable membrane were evident in many cases. Following implant placement, patients reported minor pain and swelling during the first week, and no additional complications were reported.

Four months after implant placement, during second-stage surgery, implants were asymptomatic, immobile, and osseointegrated. No peri-implant bone defects were observed by probing; no signs of infection or bleeding on probing were detected; and no mobility, pain, suppuration, or presence of peri-implant radiolucency were observed.

Block and implant survival rates were 96% (one block failed) and 95% (three implants failed), respectively. A waiting time of 3 months was applied after implant failure. Implant reinsertion eventually led to osseointegration.

Marginal bone loss at the last follow-up did not extend beyond the first thread. The mean mesial crestal bone loss was 0.96 ± 0.82 mm, and the mean distal bone loss was 0.94 ± 0.87 mm.

Histomorphometrically, the mean fraction of the newly formed bone was 40%, residual cancellous block allograft was 20%, and marrow and connective tissue was 40% (Fig 6). The mean follow-up time was 40 ± 15 months.

**Discussion**

Several studies reported the successful placement of endosseous root-form implants following
Implant explantation. In the present study, the implants placed after removing the failed implants, followed by block grafting, showed encouraging clinical outcomes.

When an implant fails, it must be removed. The recipient site should then be examined. In some cases, bone loss is negligible and a second implant placement resembles insertion into a fresh extraction site. In those cases, the implant can achieve intimate contact with the alveolar walls, but in sites with severe bone loss, this close contact with the bone may be lacking. When the latter situation occurs—or when a portion of the implant wall is exposed because of a dehiscence in the bone—guided tissue regeneration techniques can be employed using barrier membranes with or without bone graft substitute materials. As a result, pre-implant augmentative surgery is a prerequisite in many cases (especially in the anterior maxilla) to achieve a stable, long-term esthetic result.

In the present study, the severe bone loss caused either by peri-implantitis or surgical removal due to biomechanical implant failure was treated by block grafting, resulting in mean bone gain of $5 \pm 0.5$ mm horizontally and $7 \pm 0.5$ mm vertically, allowing reimplantation and rehabilitation of the edentulous areas. Similar bone gain was previously reported. However, that study used bone blocks in atrophic alveolar ridges following tooth extraction (nonrestorable or periodontal failure) or congenitally missing teeth. It might be speculated that tissue destruction following the removal of a failed implant can impair the regenerative potential of the implant site. The present study demonstrates that the regenerative potential is not hampered by previous implant failure.

In the present study, the mean percentages of newly formed bone, residual cancellous block allograft, and marrow and connective tissue were 40%, 20%, and 40%, respectively, which is comparable to previous studies. It may be speculated that age is another limiting factor for regeneration after implant failure. The mean patient age in the present study (55 years) demonstrates that bone destruction on failed implant sites can be regenerated at an older age. Cancellous bone block allografts are biocompatible and osteoconductive, permitting new bone formation after augmentation of an alveolar ridge with severe bone loss in a two-stage implant placement procedure.

The morbidity arising from autogenous bone graft harvesting—such as pain, superficial skin sensitivity disorders, and wound healing problems—is high. Moreover, many experience graft resorption, and implant survival is no better in autogenous grafted sites than nonautogenous grafted sites. As a result, patient acceptance of autogenous bone harvesting is low. In the present study, the patient acceptance for bone grafting was easier due to its allogeneic origin.

Three implants failed, all of which were located in the anterior mandible. It can be speculated that the poor vascularity of the anterior mandible and the relatively short waiting time (time between explantation and implantation) in those cases resulted in poor new bone formation at those implant sites. Waiting 3 additional months before placing another implant led to successful osseointegration of the new implants.

The results on the use of the allogenic blocks are promising. However, bone blocks can undergo resorption even after implant loading. One limitation of the present study is the two-dimensional radiograph, which does not take radiologic buccal bone maintenance into consideration.

Conclusions

Cancellous block allografts are a viable treatment alternative for a successful second reimplantation attempt, even in the presence of severe bone loss. Studies using either CBCT or a volumetric non-invasive analysis of the buccal contour should be performed in the future to assure buccal contour maintenance.

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