Tissue-Engineered Bone for Lateral Alveolar Ridge Augmentation: A Case Report

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Bone matrix derived from mandibular periosteal cells and cultivated by tissue engineering on a polymer fleece has recently been used for sinus floor elevation and augmentation. This case report focuses on clinical and histologic results after lateral ridge augmentation of a localized non–space-maintaining defect in the right posterior area of the mandible using tissue-engineered bone. Implant-supported prosthetic rehabilitation of a partially edentulous 32-year-old woman was planned involving a fixed partial denture. Preoperative investigations revealed a transversely reduced alveolar ridge width on the right side of the posterior mandible. Lateral augmentation was performed using tissue-engineered bone obtained by autogenous periosteum cells from the same area. Six months after augmentation 2 implants were placed and a bone biopsy was obtained from the augmented area. Transverse ridge dimensions were found to be enhanced. Histologic examination of the biopsy revealed dense lamellar bone. Wound healing was uneventful after all surgical interventions. This case report demonstrates the successful clinical application of tissue-engineered bone for lateral augmentation of the transversely reduced alveolar ridge. The results suggest that periosteum-derived tissue-engineered bone can be used to create a sufficient implant site not only for the sinus floor elevation and augmentation procedure for vertical bone enhancement but also for lateral augmentation. Int J Oral Maxillofac Implants 2006;21:131–135

Key words: *alveolar ridge augmentation, bone biopsy, dental implants, tissue engineering*

The application of the guided bone regeneration (GBR) in combination with bone substitution materials has proven to be successful in a number of controlled clinical studies[1–3] and is widely used for local defect regeneration prior to, or simultaneously with, implant-prosthetic rehabilitation.

Bone defects have to be separated effectively from the gingival soft tissue by a barrier and filled with blood to have the capacity to generate new bone.[4] The efficacy of different membranes for GBR has been compared in clinical investigations.[1–3,5–7] To prevent blood clot shrinking in larger defects, bone grafts or bone substitutes are used to reduce the defect volume, to stabilize the blood clot, and to maintain the space underneath the membranes.[2,8,9] Autografts, allografts, and synthetic or xenogenic bone substitutes can be used as graft material.[10–13]

Donor site morbidity must be considered when autogenous bone is used for augmentation.[14–17] The amount of bone available from intraoral donor sites is limited, however. Phycogenic, xenogenic, and synthetic bone substitution materials have disadvantages when used in ischemic areas.[18] Recently, a new method of obtaining tissue-engineered bone derived from autogenous periosteum cells has been demonstrated to be successful in animal experiments[19] and has successfully been introduced clinically for sinus floor augmentation.[18]

This case report describes the clinical management as well as clinical and histomorphologic results after the application of mandibular periosteum-derived tissue-engineered bone for the lateral augmentation of a narrow alveolar ridge prior to implant placement.

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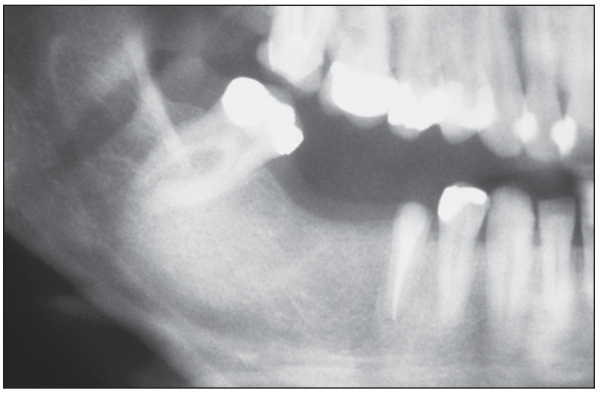

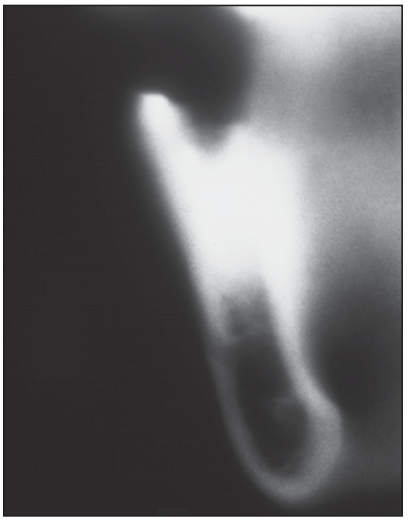

Fig 1 *(Above)* Section of the pretreatment panoramic radiograph showing the planned implant site. *(Right)* Pretreatment transverse image of the planned implant site (region of the right mandibular first molar).

CASE REPORT

A 32-year-old woman was referred for implantation and augmentation. Further implant-prosthetic treatment was planned to be performed by the referring clinician. The patient's general history revealed no pathologic findings. The clinical examination revealed a partially edentulous mandible. The right second premolar had been missing for years; the right first molar had required extraction 4 months earlier. The patient requested implant-supported fixed prosthetic restoration of this area.

A panoramic radiograph as well as a transverse cross-sectional radiograph were obtained for pretreatment evaluation of the implant site (Figs 1a and 1b). The width of the alveolar crest width was determined to be a maximum of 5 mm using a 1.5:1 magnification ruler. Radiographic examinations were performed with a Cranex Tome Ceph (Soredex, Helsinki, Finland). To prevent insufficient primary implant stability, a 2-stage approach was planned including lateral ridge augmentation using bone substitution material and membrane-guided bone regeneration, to be followed by implant placement.

After thorough clinical examination and discussion of alternative treatment options, informed consent was obtained from the patient for lateral augmentation and implant-supported fixed restoration. The patient preferred autogenous material for bone substitution. To avoid autogenous bone block transplantation, augmentation with periosteum-derived tissue-engineered bone was selected.

A periosteal biopsy sample was obtained under local anesthesia from the lateral cortex of the mandibular body in the apical region of the first molar area by an intraoral buccal approach. The periosteal tissue was stored, packed, and sent following the instructions of the BioSeed Oral Bone protocol (Bio Tissue Technologies, Freiburg, Germany). The BioSeed oral bone transplants were prepared on 3-dimensional fleeces consisting of nonwoven polyglactin-910 fibers (Vicryl), which were connected by poly-p-dioxanon (PDS) bonding sites (Johnson & Johnson/Ethicon, Somerville, NJ). The polymer content of the BioSeed oral bone transplant was less than 10%. The osteoblast count was determined to be 11.2 to 18.7 million vital cells/cm^3 fleece; it met the minimum quality requirement for bone transplantation.[19,20]

Five weeks later, the tissue-engineered bone transplant preparation was completed and the treatment was continued. Lateral ridge augmentation was performed under local anesthesia by a midcrestal incision and elevation of a full-thickness flap. The transplant recipient site was prepared by small perforations of the cortical bone to ensure bleeding from the cancellous bone (Fig 2). The bone transplant was provided in the form of autogenous, premineralized 3-dimensional bone cell transplants on bioresorbable polymer fleeces. A total of 6 polymer fleeces containing the bone tissue transplants were removed from the storage container, rinsed thoroughly with sterile saline, and put on the prepared buccal surface of the alveolar ridge (Fig 3). After a releasing incision of the basal periosteum to enhance flap mobility, the site was covered by a porcine collagen membrane (Bio-Gide; Geistlich Biomaterials, Wolhusen, Switzerland), and primary wound closure was obtained.

Six months later the patient presented for further treatment. Following midcrestal incision and full-thickness flap elevation, enhanced ridge width was

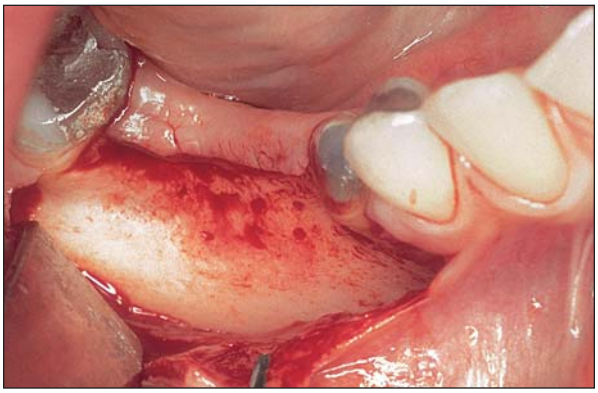

Fig 2 The augmentation site. The lateral cortical layer was prepared for the graft positioning.

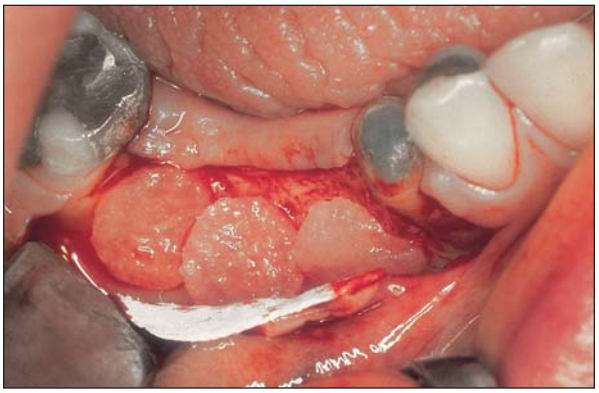

Fig 3 Three BioSeed Oral Bone fleeces were placed on the lateral alveolar ridge. A Bio-Gide membrane was prepared to cover the fleeces after completion of the augmentation.

found compared to the original condition. The former augmentation site showed neither signs of bone resorption nor inflammation (Fig 4). The periosteum of the flap was completely intact without clinical signs of scar formation. Following implant site preparation, a trephine bone biopsy was obtained from the lateral aspect of the former augmentation area in the region between the first molar and second premolar. A bone cylinder 2 mm in diameter and 6 mm in length was removed. The bone was found to be dense during trephine drilling and implant site preparation. Two implants (Camlog screw-type cylinders; Altatec Biotechnologies, Wurmberg, Germany) were placed, completely surrounded by bone.

The bone biopsy material was prepared for routine histopathologic examination by placing it in 4% formalin for fixation, dehydration, and embedding in methylmethacrylate resin (Technovit 9100; Heraeus Kulzer, Bensheim, Germany). Serial Giemsa-stained[21] sections 10 mm thick were evaluated. These representative sections obtained 2 mm and 4 mm from the outer cortex of the augmented area showed dense lamellar bone rich in bone cells. The formation of intermediate lamellae was irregular, and functional maturation was incomplete (Figs 5a to 5d).

Healing abutments were placed 3 months later, after local midcrestal incisions were made above the implants. Implant stability was assessed at the time of healing abutment connection by instrument pressure, a percussion test, and the exclusion of implant rotation on abutment placement. The implants were found to be osseointegrated.

The patient was referred to her local dental practitioner for further prosthetic treatment. Healing was uneventful after all surgical interventions. The patient was completely satisfied with the treatment course as well as the results.

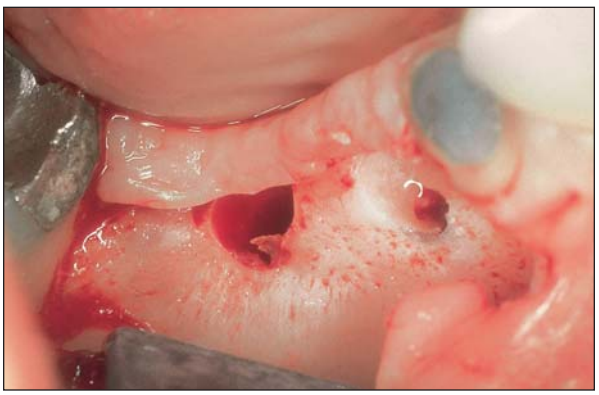

Fig 4 The augmented area 6 months after bone augmentation at the time of implant site preparation. The augmented lateral cortical bone showed no signs of resorption nor inflammation.

DISCUSSION

The use of periosteum-derived tissue-engineered bone is a new method for providing bone substitutes for the treatment of alveolar ridge defects. The preliminary results of a clinical study on the application of periosteum-derived tissue-engineered bone in sinus floor augmentation procedures suggested this approach as a reasonable alternative for augmentation procedures.[22] Four months after augmentation, implants were placed into mineralized trabecular bone with remnants of the polymer fleece.[18] The polymer fleeces containing the bone cells were not exposed to lateral forces, and little is known yet concerning the long-term results (eg, long-term height reduction or resorption of the augmented tissue).

Fig 5 *Histologic appearance of bone biopsy material obtained at different depths (2 and 4 mm).*

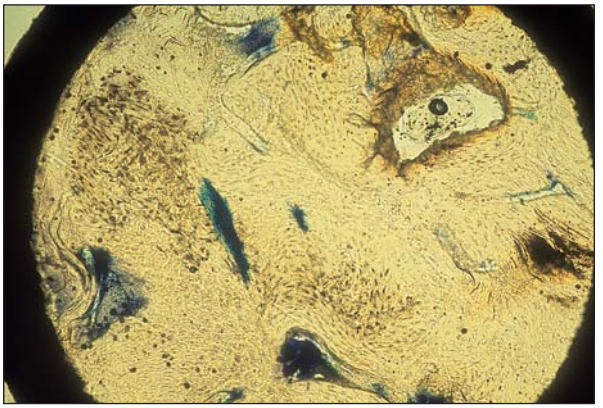

Fig 5a Overview of tissue taken from 2 mm deep. The newly formed bone shows irregular formation (Giemsa; original magnification ×16).

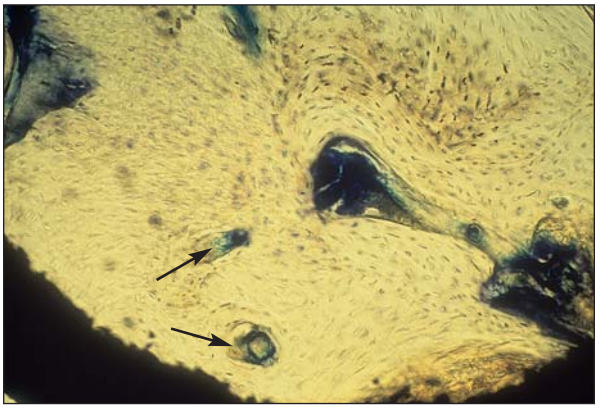

Fig 5b Section from *(a)* at a higher magnification showing wider central vessels *(arrows)* of the primary osteons (original magnification ×40).

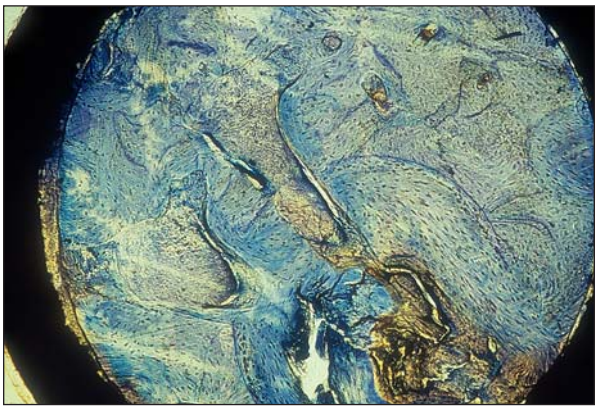

Fig 5c Overview of tissue taken from 4 mm deep. The newly formed bone shows irregular formation, similar to outer biopsy layers (Giemsa; original magnification ×16).

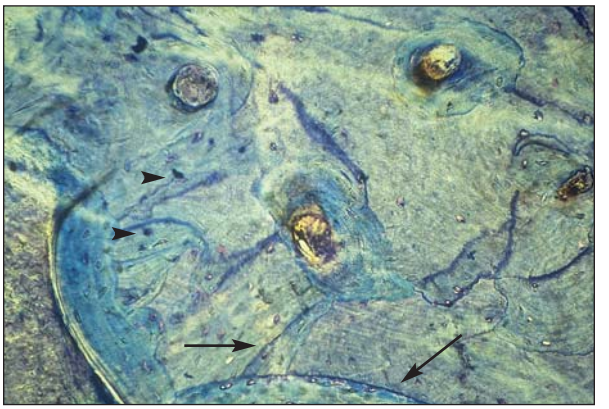

Fig 5d The newly formed lamellar bone with primary osteons and smaller central vessels *(arrowheads)*, and secondary osteons with characteristic cement lines *(arrows)* (magnification ×40).

The reported treatment course of the patient demonstrated the successful use of periosteum-derived tissue-engineered bone cells for lateral augmentation. The soft consistency of the polymer fleeces with bone cells requires a dense packaging to obtain sufficient ridge width enhancement in lateral augmentations. For primary wound closure, flap mobilization was performed by releasing incisions into the basal periosteum. To prevent soft tissue ingrowth into the augmented area resulting from the interrupted periosteal integrity and to prevent the risk of limited healing in case of premature membrane exposure, a resorbable collagen barrier membrane was used. Collagen barriers have been proven to provide reduction of the exposed area as well as complete soft tissue healing within 2 to 6 weeks even in cases of premature exposure.[2,3,7] Although the augmented area was exposed to lateral forces of soft tissue pressure, an increase of ridge width was revealed during the implant site preparation. Alternatively, the use of a space-maintaining titanium mesh or a titanium-reinforced membrane could have been considered.

The histologic results showed dense lamellar bone. The formation of intermediate lamellae was found to be irregular. This might be the result of incomplete functional maturation and/or the irregular setting of bone cells within the polymer fleeces. This bone quality is in contrast to earlier findings; in a previous study of the use of tissue-engineered bone for sinus floor augmentation, young, mineralized woven trabecular bone was found 4 months after augmentation.[18] These findings may result in 2 hypotheses: *(1)* the mandibular periosteum-derived tissue-engineered bone undergoes a remodeling which corresponds to the bone quality of the trans-

plant recipient site; and *(2)* use of the polymer fleeces with tissue-engineered bone will provide enhanced bone density when exposed to soft tissue pressure. These hypotheses should be considered for further investigation in comparative clinical studies with larger sample sizes.

The logistic requirements to provide autogenous blood conserves for storage of tissue samples have been further reduced by the tissue engineering company. However, the timing of treatment steps, and the availability of the patient and the treatment facilities require a well-organized schedule. Although an additional surgical step is necessary to obtain periosteum cells, this intervention is very limited. Wound healing was shown to be uneventful, without any late effects. The use of tissue-engineered bone derived from periosteum cells offers great potential in the augmentation of alveolar ridge defects and other craniofacial bone defects. Furthermore, its use prevents morbidity of transplant donor sites when autogenous bone is considered for defect filling.

This case report suggests that the clinical application of tissue-engineered bone can provide a reasonable alternative for bone substitution in augmentation procedures, not only for sinus floor augment-ations, but also for lateral augmentation of the narrow alveolar ridge.

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