Ridge augmentation for an atrophied posterior mandible—Part I

NanoBone block versus allograft bone block

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_Introduction

Alveolar bone first forms when the Hertwig's root sheath develops from the tooth germ. The alveolar bone does not form in the absence of primary or secondary tooth development. The close relationship between the tooth and the alveolar process continues throughout life. Wolff's Law (1892) states that bone remodels in relation to the forces applied. Every time the function of the bone is modified, a definite change occurs in the internal architecture and external configuration.

Bone needs stimulation to maintain its form and density. Roberts et al.[1] report that a 4% strain to the skeletal system maintains bone and helps balance resorption and formation. When a tooth is lost, the lack of stimulation to the residual bone causes a decrease in trabeculae and bone density in the area, with loss in external width and height of the bone volume, and eventually leads to atrophic edentulous ridges. A primary reason to consider dental implants for replacing missing teeth is the maintenance of alveolar bone. A dental implant placed into the bone serves both as an anchor for the prosthetic device and as a means of preventive maintenance in dentistry. When stress and strain are applied to the bone surrounding the implant, the bone trabeculation decrease after tooth extraction is reversed. There is an increase in bone trabeculae and density once the dental implant has been placed and is functional. In addition, the dental implant helps maintain the overall volume of the bone.[2]

Ridge augmentation is designed to widen ridges prior to implant placement. Various grafting procedures have been utilised for grafting an edentulous ridge, including an allograft, autogenous graft or xenograft with or without a titanium reinforced membrane, ridge splits, distraction osteogenesis, and onlay grafting with an autogenous or allograft bone block. Traditionally, onlay ridge augmentation has entailed the use of an autogenous graft from a separate intraoral surgical area such as the ramus, chin or posterior ridge, or from extra-oral sites such as the tibia, iliac crest or ribs.[3] The need for a second surgical site could be eliminated were a graft material such as an allograft bone block or NanoBone block be shown to provide adequate volume and quality of new bone in atrophic sites. Tissue engineering is an interdisciplinary field that applies the principles of engineering and life sciences to the development of biological substitutes that can replace, restore, or improve tissue function.[4] One tissue-engineering approach is the use of 3-D scaffolds to provide a suitable environment for tissue formation. Ideal scaffolds act as a guide supporting cell growth and differentiation and utilise the deposition of regenerated tissue.[5] In bone-tissue engineering, the scaffold should be biocompatible, osteoconductive and osteoinductive. The scaffold allows cells to attach and proliferate and to form an extracellular matrix. It should have an open and interconnected pore structure (with a porosity of > 90%) that allows nutrients to

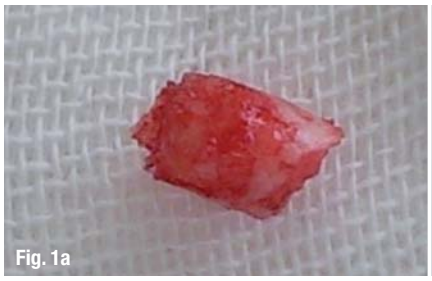
Fig. 1a

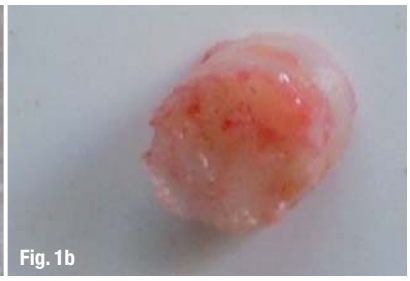
Fig. 1b

penetrate into the scaffold *in vitro* and then vascularisation to occur *in vivo*.[6] It should also degrade at a suitable rate to match the rate of tissue formation.[7] However, micron-sized hydroxyapatite (HA) particles might lead to a low resorbability and fragile constructs.[8] Overcoming the constraints in applying calcium phosphate ceramics as well as enhancing their bio-reactivity has become the latest concern in biomaterials. Thereby, unique advantages of nanotechnology can be explored. Nanotechnology can help improve the bio-reactivity of HA as a bone constituent, thus increasing the biomaterial-bone interface. The chemico-physical and biological properties of HA are strictly related to their dimensions, the regulation of which requires a high level of chemical control at the nanoscale. Because of their composition, structure and their nano-dimensional and –morphological likeness to bone crystals, biomimetic HA synthetic crystals are believed to be a great hope for orthopaedics. In comparison to particle-sized traditional materials, nanostructured biomimetic materials show a better performance, resulting from their large surface-to-volume ration and rare chemical and electronic synergistic effects.[9]

In addition, the bone-mineral phase with carbonated HA crystals of a length of 100 nm, a width of 20–30 nm and a thickness of 3–6 nm results in a biomimetic need for synthesising with similar nanoscale dimensions. Moreover, a low crystallinity, a non-stoichiometric composition and crystalline disorder as well as the presence of carbonate ions in the crystal lattice are indicated. The good biological quality of HA, for example non-toxicity, its lack of inflammatory and immunity response as well as high bio-resorbability are increased even more by decreasing the crystallinity of synthetic apatite.

Size and crystallinity of the HA particles are important with regard to stability and inflammatory response in collagen-HA implants. In bones, carbonate-substituted HA crystals are mineralised in small gaps of the collagen fibrils and have been found to have a length of 50 nm, a width of 25 nm and a thickness of 2–5 nm.[10] As the local source of calcium to the surrounding cells, they become integrated with collagen fibrils, thus achieving the high mechanical properties of bone. Nontheless, small sintered particles of a size of less than 1 µm have been warned against when used in bone implants. Reasons for this are their high inflammatory response[11] and their cell toxicity *in vitro*.[12] Contrarily, smaller plate-like particles (200 nm x 20 nm x 5 nm) have been shown to create increased osteoblastic adhesion and proliferation when compared to larger HA particles, such as carbonate-substituted HA particles, unsintered and produced at physiological temperetures.[13]

A nanocrystalline HA in a silica-gel matrix (NanoBone, ARTOSS) with a very large internal surface (about 84 m^2/g) was used in this study.[14] In addition, nanocristalline HA showed faster bone formation and resorption in animal studies when compared to commercially available HA, tricalcium phosphates and gelatine sponges[15], resulting from their porous structure, rough surface and interconnecting pores of 10–20 nm of the silica gel.

Signs of osteoconduction and osteoinduction,[16] high biocompatibility and angiogenic response[17] became visible in histological and immunohistochemical investigations after implantation. Furthermore, it was postulated that nanocrystalline HA has osteoconductive and biomimetic properties and is integrated into the host's physiological bone turnover at a very early stage.[18] Newly formed bone of limited quantities was found at three months of healing[19], while new trabecular bone was found at six month of healing[20] in recent histological investigations of human biopsies from sinus augmentations with nanocristalline HA.

The aim of the present study was to compare the clinical outcome of and radiographic bone changes in augmented ridges utilising a synthetic NanoBone block versus an allograft bone block, and to investigate histologically the success of a synthetic NanoBone block versus an allograft bone block for augmentation.

_Materials and methods

Subject selection

Twenty patients ranging between the ages of 35 and 55 were included in this study. All patients selected for this study required bone augmentation procedures because of severe alveolar ridge atrophy in the posterior mandible, either unilateral or bilateral, with standing anterior teeth. Furthermore, the participants were healthy and free from any systemic conditions. Other than any systemic condition that might have affected bone formation, osseointegration or soft-tissue rehabilitation (such as immune systemic disease, diabetes, pulmonary diseases, renal and cardiovascular diseases, and blood diseases), exclusion criteria were malignant neoplasias, hepatitis, drug abuse, chemotherapy and radiotherapy. In addition, smokers were excluded from the study. All the participants were informed about the study and completed an informed consent form. The participants were divided randomly into two groups of ten patients. The first group (group A) underwent ridge augmentation using a NanoBone block and the second group (group B) underwent ridge augmentation using an allograft bone block.

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Preliminary subject evaluation

A preliminary clinical and radiographic evaluation (panoramic tomogram and CT scan) was performed. The results, along with the dental casts, confirmed posterior mandibular atrophy.[21]

Study materials

A NanoBone block (Artoss Co) was used for group A and an allograft bone block (Fisiograft, Ghimas) was used for group B. The tioLogic dental implant system (Dentaurum Implants) was used for both groups in a two-stage procedure.

Ridge augmentation

Antibiotic prophylaxis (1 g Augmentin, orally) was administered to all patients two hours preoperatively. After preoperative medication, posterior mandibular ridge augmentation was carried out under local anaesthetic combined with a sedative (5 mg midazolam, intramuscularly).[21]

Surgical procedures

Kazanjian's vestibuloplasty was performed according to the method described by Khoury et al.[22] After exposure of the bone surface, bleeding points were created in the vestibular sulcus using a fine round bur.[23] The bone block was adapted to the ridge using a scalpel. Once the blocks were flush with the ridge, it was affixed by a two-hole micro-plate and two micro-screws, resulting in rounded edges. A lingual pedicled flap was then reflected and sutured to the periosteum as far as possible in the vestibule to prevent relapse of the muscle attachment, representing a second-layer closure over the grafted area.[22]

A Systemic antibiotics (1 g Augmentin twice a day for ten days) and non-steroidal analgesic (400 mg Ibuprofen twice a day for three days) were administered to both groups post-operatively. The participants were advised to follow a soft-food diet for two weeks and an appropriate oral hygiene routine, including rinsing with 0.2% chlorhexidine digluconate twice a day. Sutures were removed seven to ten days after the surgical procedure. The participants attended a clinical examination every week in the first month after surgery, and twice in the second and third months. They were not permitted to use removable dentures. Radiographic assessment (panoramic tomogram and CT scan) was carried out after six months.

Efficacy of the ridge augmentation

Standardised measurements for each patient were recorded before and after ridge augmentation.[24] An acrylic reference stent was fabricated for each patient to assist in standardisation of all measurements. The stent was designed to cover the occlusal surface of the teeth adjacent to the augmentation site. Each stent had predetermined measurement points to determine the alveolar height using a periodontal probe on the occlusal side and to determine the alveolar width using a calliper on the buccal and lingual sides.

Assessment of alveolar ridge dimensions by CT

Bone induction was compared by CT scans before (baseline) and six months after ridge augmentation. The holes in the stent were filled with gutta-percha to provide radiopaque landmarks to indicate the locations for comparative ridge measurements. The image with the clearest gutta-percha imprints was selected for measurement of the buccal and lingual aspects. The measurements were performed using a software measurement tool.[24] Measurements were taken at baseline and six months after augmentation.[25] The density of the newly induced bone was assessed using CT with the aid of a standard density block. The change in bone gain or bone loss after treatment is the six-month measurement minus the baseline measurement. Alveolar ridge dimensions were assessed by measurements.[26] Alveolar height was determined with a periodontal probe, measuring the distance from a fixed point on the occlusal surface of the stent to the crest of the alveolar ridge. Measurements were taken with the probe placed perpendicular to the ridge. The change in bone height after treatment is the six-month measurement minus the baseline measurement. Buccolingual width measurements for each patient were recorded using a calliper device, which was sterilised properly and used for each patient. The change in bone width after treatment is the six-month measurement minus the baseline measurement.

Histopathological examination

During the placement of the dental implant, full-thickness bone core biopsies were obtained by a trephine (Figs. 1a & b). The biopsies were immediately stored in 10% buffered formalin, decalcified in EDTA and processed for haematoxylin-eosin stain and Masson's trichrome.[21] Each specimen was evaluated histologically._

Editorial note:
To be continued with results, discussion and conclusion and an extensive photo documentation in implants 2/2013.

A complete list of references is available from the publisher.

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