

Abstract

This study presents the results of different augmentation procedures using the new and nanostructured bone substitute (BS) NanoBone™ with special regard to the histologic features and demonstrates that former therapy protocols can be changed to remarkable shorter healing periods which can be carried out with reliable results. The structural changes were analysed histologically and the cellular ingrowth of bone forming cell lines and blood vessels could be verified.

Based on 86 sinus floor elevations (SFE) and 75 lateral augmentations (LAT) performed on average 3 or more years ago there is no measurable difference in bone height and dimension. Histomorphometry of SFE samples showed about 40 vol.% of de novo bone formation after only 2-3 months which must be compared to other BS.

The preliminary results following augmentations with NanoBoneBlocks™ are encouraging and suggest that this might be a way to abandon the transplantation of bone blocks of other origin.

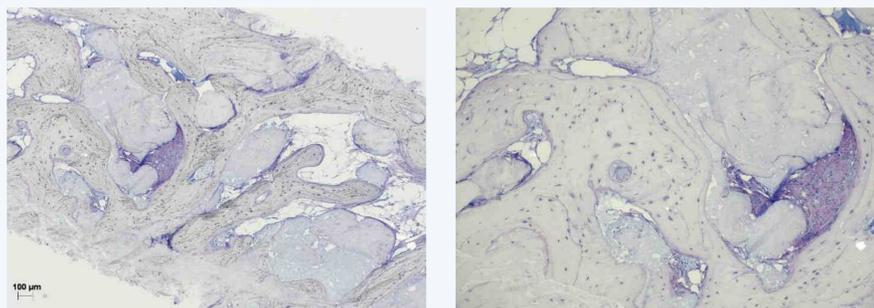
Background and Aim

The bone substitute NanoBone™ (NB) is produced at relatively low temperatures and consists of nanocrystalline hydroxyapatite embedded in silica gel. The great inner surface of about 80m² per gram and the high porosity attracts circulating mesenchymal stem cells and initiates the invasion of connective tissue, blood vessels and differentiation of stem cells into fibroblasts, pre-osteoblasts, osteoblasts, osteoclasts and pericytes at early stages and thus promotes the formation of new bone that soon changes from woven to lamellar bone (fig. 1, male, 42yrs., 64 days after SFE, a: scale x100, b: scale x200).

Some granular bone substitutes (BS) of different composition have reached kind of standard and their behavior is well documented but the protocols for the use of those BS require far longer healing times ranging from recommended 6 to 12 months in 2-stage procedures as well as in simultaneous augmentation and insertion of implants.

The introduction of NanoBoneBlocks™ opens a pathway to augmentation procedures that previously could only be performed by using autogenous, allogenic or xenogenic transplants which require either a second/ harvesting operation or are bearing other potential risks.

V Fig. 1a-b

**Methods and Materials**

From May 2009 particular NanoBone™ (NB) was applied for lateral, vertical and combined augmentations of the alveolar process (LAT) and sinus floor elevations (SFE). This study includes 75 LAT- patients and 86 with SFE. Since October 2008 NanoBoneBlocks™ were used for lateral/vertical augmentations and socket preservation procedures. The advantage of the latter was the fact that even in cases where the stabilization of particular BS is difficult or impossible blocks not only were fixed by osteosynthesis screws but could maintain the desired volume even in areas where movement of mimic muscles was active.

Our therapy protocol based on healing periods 2-3 months for SFE, 3-4 months for LAT and initially 4 months for block augmentation which applies for one stage as well as two stage procedures. Implants generally get functional loading after 3 months. In those two stage cases with SFE bone specimen were collected by trephine drills during preparation of the implant layers. In 8 cases where bilateral SFE had to be carried out we used NB on one side and bovine bone mineral (BBM) (BioOss™) on the other to enable intraindividual comparison.

The bone cylinders were fixed, some decalcified and some embedded in methacrylic for either standard processing or cutting grinding technique (DONATH). Staining, histological examination and histomorphometry was performed by the co-authors (see also MEIER).

Results

Six of the 149 patients in the LAT and SFE groups were lost to follow-up. In the remaining collective all of the 358 implants inserted in the augmented areas are still in function and unsuspecting. Radiological examinations to estimate possible bone loss showed no regression above the variation of measurement. In the SFE group the bone height was measured from preoperative to last FU-X-ray. Starting with residual bone height of 0.5 to 4mm the gain in vertical dimension ranged from 7 to 13.5mm in median plus 8.7mm. After 3-4 months the former basal cortex of the sinus disappeared indicating the complete osseous reparation (fig.2, fem. 47yrs. a:3 months after SFE, post impl., b:Follow-up 24 months after extraction of 24 and instant implantation). Histomorphometry carried out on bone cylinders taken 2-3 months after SFE revealed the following ratio of the different bone compartments in the augmented part (median values): New bone (woven and lamellar):39,5%, bone marrow: 44.7% and remainders of NanoBone: 17.7%. Those few BBM cases varied considerably with 17-24% new bone and up to 39% of remaining BS. More important is the clinical impression that central portions were not organized and still weak which corresponds to the low rate of turnover.

In the LAT group the thin biotype of the gingival tissues seems to influence the stability of the buccal onlay but due to difficulties in the clinical assessment of the amount of new bone no hard data were gained. In all patients the aesthetic outcome was satisfying and stable with no "grey" gingivae, the estimated lateral gain ranged from 3 to 5mm.

Augmentation with NanoBoneBlocks™ started in October 2008. The clinical results and histology show the same early osseous regeneration, penetration with cells, blood vessels and de novo bone formation as known from the particular NB. The block is stable in volume and no further (titanium-) cover is necessary because bone is growing through before remarkable resorption takes place. Fig. 3a-e show the treatment of a combined defect, fem.57yrs. with NB-blocks.

Fig. 2a-b >



V Fig. 3a-e

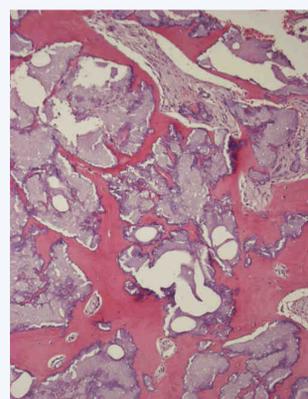
**Conclusions**

Our results after now up to 52 months follow-ups demonstrate that NanoBone™ is a reliable BS and presents good bone regeneration in short healing periods which allows to reduce the healing periods considerably.

The nanostructure of this BS attracts mesenchymal stem cells and promotes their differentiation with early and abundant formation of blood vessels and bone formation throughout the whole augmentation material.

The NanoBoneBlock™ might be an alternative to (replace?) bone transplants.

<Fig. 4: 3 months post LAT, fem. 63 yrs., HE x200

**References**

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