

# Ridge augmentation for an atrophied posterior mandible—Part II

## NanoBone block **versus** allograft bone block

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### \_Introduction

The aim of the present study was to compare the clinical outcome 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 ridge augmentation.

*In the previous issue of implants: international magazine of oral implantology, the authors gave a detailed introduction to their topic and explained the materials*



Fig. 1

- Fig. 1\_Incision line opening in group A.
- Fig. 2\_Partial graft exposure in group A.
- Fig. 3\_Screw exposure.
- Fig. 4\_Screw loss in group A.
- Fig. 5\_Complete graft exposure in group A.
- Fig. 6\_Inflammation in group A.
- Fig. 7\_Inflammation in group A.



Fig. 2



Fig. 3



Fig. 4



Fig. 5



Fig. 6



Fig. 7



**Figs. 8a & b** Inflammation in group B.

and methods used in their study. In this issue, their report is completed by the results of their investigations and an extensive discussion.

## Results

### Clinical results and complications

– Group A: During intra-operative procedures, NanoBone augmentation was associated with fracture of the NanoBone block during augmentation in one case because it was fragile and fractured easily. In the post-operative period, soft-tissue complications such as the incision line opening (one case, Fig. 1), a small perforation of the mucosa over the grafted bone (two cases, Fig. 7), and graft infection (one case, Fig. 6) occurred. In addition to partial graft exposure (Fig. 2), screw exposure (Fig. 3) and screw loss (Fig. 4), one block graft was completely exposed (30 days after surgery) and lost (Fig. 5). Treatment was initiated as soon as possible. Necrotic soft tissue was removed, and the NanoBone block was leveled with the soft tissue using a high-speed bur. The area was immediately and thoroughly irrigated with chlorhexidine. Patients were prescribed an additional week of oral antibiotics and instructed to apply chlorhexidine gel over the affected area twice a day, as well as to refrain from chewing on the grafted site until mucosal healing was complete.

– Group B: No intra-operative complications were present during the allograft augmentation. In addition, no post-operative complications were present after the ridge augmentation or at the time of the implant surgery, except for one case of infection (Figs. 8a & b).

– Both groups: The regenerated ridges healed uneventfully and no evidence of serious adverse local reactions, that is, foreign-body reaction, pain, dysaesthesia, inflammation was observed in any patient throughout the study.

### Bone-gain clinical measurements

Analytical data regarding the increase in alveolar bone height and width was obtained before and after ridge augmentation and at the time of implant place-

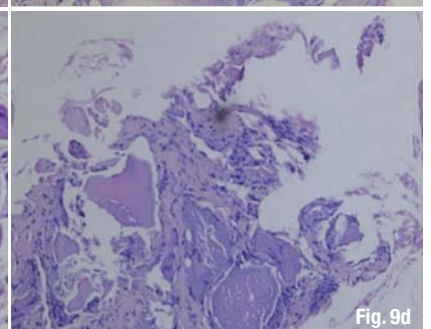
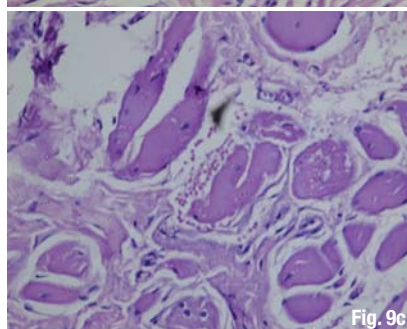
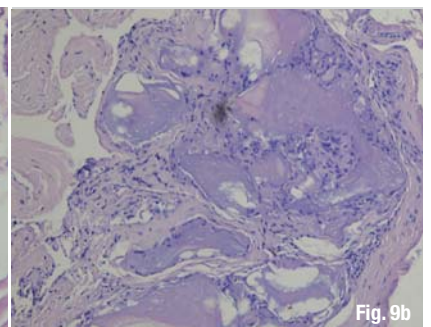
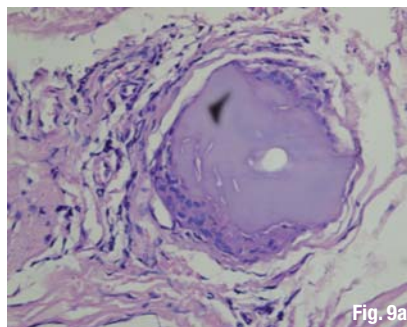
ment. The mean and standard deviation of the augmentation volume obtained were calculated (Table 1 & Fig. 12).

In group A, the amount of bone height gained was  $2.25 \pm 1.31$  mm ( $P < 0.001$ ) and bone-width gain was  $2.3 \pm 1.49$  mm ( $P < 0.002$ ), while the amount of bone height gained was  $0.75 \pm 0.97$  mm ( $P < 0.001$ ) and bone-width gain was  $0.45 \pm 0.55$  mm ( $P < 0.002$ ) in group B. In group A, the amount of bone-height loss was  $2.75 \pm 1.31$  mm ( $P < 0.024$ ) and bone-width loss was  $2.9 \pm 1.88$  mm ( $P < 0.037$ ), while the amount of bone-height loss was  $4.05 \pm 1.01$  mm ( $P < 0.024$ ) and bone-width loss was  $4.4 \pm 0.93$  mm ( $P < 0.037$ ) in group B.

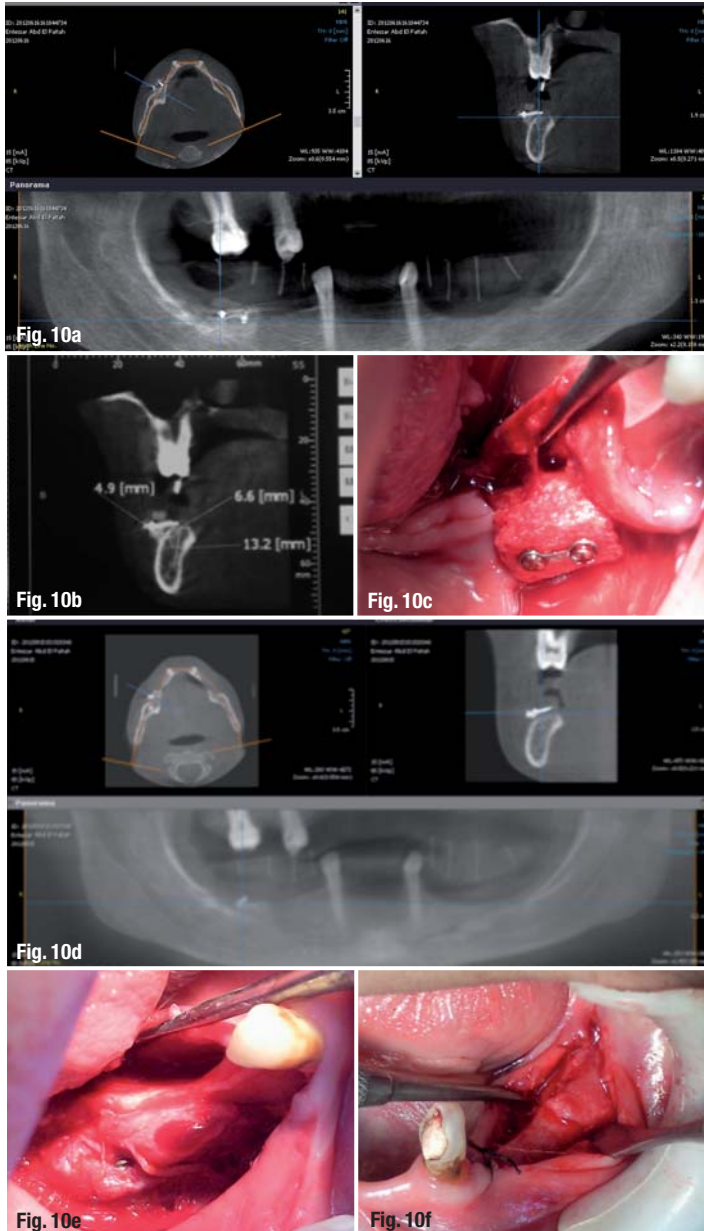
### CBCTEvaluation (Figs. 10a, b & d)

It was surprising that Nanobone density was greater in group A after grafting. This was because of the presence of mineral in NanoBone, which acts as a scaffold, degrading progressively and being replaced by new bone. The new bone is premature with a low mineral density and is therefore not radiopaque after six months.

**Figs. 9a–d** Histological evaluation.







**Fig. 10a**\_ CBCT immediately after ridge augmentation (Nanobone on the right side and Fisiograft on the left side)

**Fig. 10b**\_ measurements of CBCT immediately after Nanobone ridge augmentation.

**Fig. 10c**\_ Clinical view of Nanobone block fixation during augmentation procedures.

**Fig. 10d**\_ CBCT six months after ridge augmentation (Nanobone in Rt side and Fisiograft in Lt side; NB. Nanobone graft not appears radiopaque in CBCT cross section).

**Fig. 10e**\_ Clinical view of Nanobone graft six months after augmentation (at the time of implant placement).

**Fig. 10f**\_ Clinical view of Fisiograft six months after augmentation (at the time of implant placement).

By comparing CBCT scans before and six months after the augmentation procedures (Figs. 10 a, b & d), it was found that CBCT is not a suitable means of evaluation for ridge augmentation with either NanoBone or allograft bone blocks.

*Histological results*

Histological evaluation showed rapid incorporation of the NanoBone block graft at six months, as ev-

idenced by newly formed bone containing viable osteocytes.

**\_Discussion**

Reconstruction of the posterior mandible is challenging since deficiency in bone and mucosa is required due to the deformity.<sup>27</sup> Unlike the maxillary sinuses, the alveolar ridge does not provide a natural cavity to contain particulate grafting material.<sup>28</sup> Therefore, the graft must have sufficient strength and rigidity to attach to the recipient site and 3-D stability to withstand muscular forces.<sup>29</sup> The availability of autogenous bone block grafts from intra-oral sites is often a limitation in treatment possibilities.<sup>30</sup> Among the alternatives to autogenous bone blocks are the synthetic NanoBone and allograft bone blocks. Studies have reported that allograft fresh-frozen bone may provide results equivalent to those achieved with autogenous bone grafts.<sup>30-33</sup> Currently, however, only insufficient evidence is available regarding treatment efficacy of allograft bone blocks, for example volumetric changes and remodelling/incorporation within the host bone, and the long-term survival rates of subsequently inserted implants,<sup>30</sup> and few studies have been conducted on the innovative NanoBone block.<sup>23</sup> The success of grafting procedures highly depends on primary soft-tissue closure, which warrants healing by primary intention and entails only marginal soft-tissue collagen formation and remodelling. In addition, it reduces postoperative discomfort and provides a significant step in predictable bone regeneration. Incision line opening is the most frequent postoperative complication in the initial healing phase of intraoral bone grafting.<sup>34</sup> It results in contamination or loss of the graft as well as a delay or abolition of the vascularisation and may halt bone growth.<sup>35</sup> The high frequency of incision line opening in bone block grafting is caused by the strain on the overlying tissue, which must cover larger quantities of bone. Furthermore, the local growth factor of the soft tissue is low under the reflected flaps which are positioned over a graft material or barrier membrane and not on the host bone.<sup>36</sup> In the present study, we used Kazanjian's vestibuloplasty instead of a crestal flap. Whether to make crestal or vestibular incisions during bone-block augmentation depends on the following factors. Vestibular incisions may be more advantageous than crestal incision because of better protection of the underlying grafted bone.<sup>22</sup> They are also claimed to increase the blood supply to the lingual flap from the floor of the mouth. In addition, the lingual flap is not completely dissected from the inner aspect of the mandible and helps maintain the vestibule. This decreases muscle tension, preventing movement on both sides of the wound, which prevents wound dehiscence and incision line opening.



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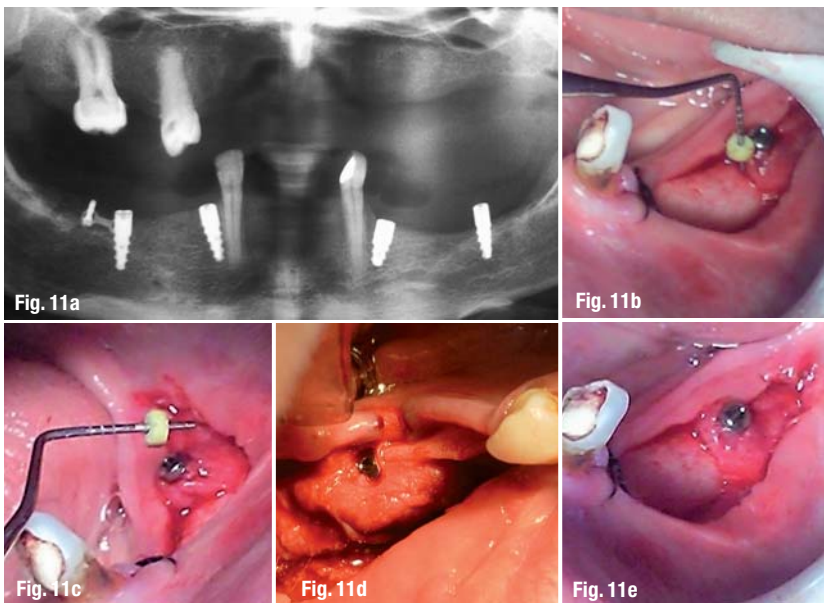
	Alveolar height measurements (mm)					Alveolar width measurements (mm)				
	BA	AA	BIP	BG	BL	BA	AA	BIP	BG	BL
<b>Nanobone block group</b>	13.1 +2.8	8.2 +2.7	10.45 +2.7	2.25 +1.31	2.75 +1.31	3.8 +0.85	9.7 +1.13	6 +1.71	2.3 +1.49	2.9 +1.88
<b>Allograft bone block group</b>	14.9 +2.9	9.9 +2.9	10.7 +2.8	0.75 +0.97	4.05 +1.01	4.60 +0.77	9.50 +0.94	5.05 +1.1	0.45 +0.55	4.4 +0.93
<b>t. test</b>	1.40	1.38	0.196	2.890	2.047	2.19	0.429	1.44	3.67	2.025
<b>p. value</b>	0.177	0.184	0.846	0.001	0.024	0.042	0.635	0.165	0.002	0.037

**Table 1** Comparison of bone gain in groups A and B (BA: before augmentation; AA: after augmentation; BIP: before implants placement; BG: bone gain; BL: bone loss).

This is a frequent complication after crestal incision, especially in the mandible, owing to muscle tension, which may compromise the prognosis of the underlying grafted bone. It was clear from our results that the clinical complications, either during the procedures or during the healing period, were greater in group A than those observed in group B. We assume that this complication arose because NanoBone blocks have sufficient strength and rigidity to attach to the recipient site. Furthermore, NanoBone has 3-D stability and maintains its strength with little or no resorption when properly used. This results in an increase in tension on the overlying mucosa. In comparison, allograft bone blocks are resorbed rapidly, which decreases the tension on the overlying mucosa. This finding is consistent with that of Spin-Neto et al.,<sup>37</sup> who state that a loss of about one-third of the grafted block volume with allografts should be expected. They therefore recommend that this finding be kept in mind during treatment planning involving alveolar ridge augmentation with allografts, since it indicates the need for allograft bone blocks of larger dimensions to compensate for their considerable re-

sorption. The majority of adverse events occurred as a result of improper contouring or inappropriate closure techniques, which resulted in secondary soft-tissue dehiscence and infection. Clinical training is therefore strongly recommended for clinicians unfamiliar with NanoBone. The clinical complications observed in group A can be reduced by proper flap design and careful follow-up treatment during the healing period. It is worth noting that protecting the bone block from maxillary tooth pressure either by tooth grinding or by constructing an upper denture to maintain centric occlusion can prevent the bone block from fracture and the overlying mucosa from tearing. Another important result is that NanoBone exposed during the healing period was placed vertically to increase the alveolar ridge height. This finding is consistent with Barone et al.,<sup>38</sup> who postulate in their study that horizontal ridge augmentation has a more predictable outcome than vertical ridge augmentation. The observed difference in resorption between the two groups may be due to the different architecture of the NanoBone and the allograft bone blocks. It has previously been demonstrated that different graft architectures have a direct influence on the dynamics of bone remodelling.<sup>39</sup> The greater resorption of the allograft bone blocks can also be explained by inadequate revascularisation, less bone in-growth inside the grafted block and/or a smaller number of cells involved in the remodelling process of this type of bone graft.<sup>40-42</sup> NanoBone is a synthetic HA with nano-pores manufactured in a sol-gel process in the presence of SiO<sub>2</sub>, so that it is degraded completely by osteoclastic activity. At the same time, the osteoblasts form autogenous bone and NanoBone is substituted by bone. In the present study, bone-width gain was measured both clinically and using CBCT. It was found that clinical measurement was an effective method to determine bone gain. This finding is consistent with that of Cheng Chen et al.<sup>24</sup> The results of the present study demonstrated that NanoBone blocks provided a statistically significant increase in bone gain after the grafting procedure, while the bone gain with allograft bone

**Fig. 11a** Panoramic X-ray after Tiologic implant placement, in Nanobone graft (right side) and in Fisiograft (left side). NB. Fisiograft does not appear radiopaque.  
**Figs. 11b & c** Measurement of the Fisiograft height, invisible in X-ray.  
**Fig. 11d** Tiologic implant in Nanobone graft (right side).  
**Fig. 11e** Tiologic implant in Fisiograft (left side).



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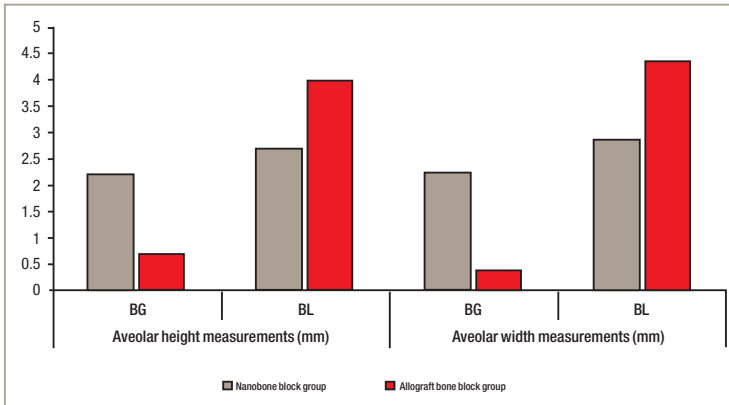
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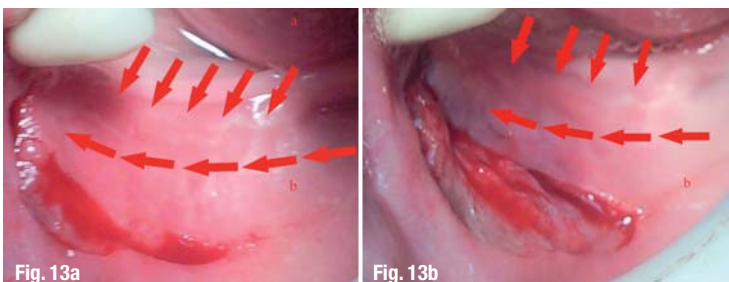


**Fig. 12** Comparison of bone gain and loss between Nanobone and Fisiograft groups.

blocks was not statistically significant. Ehrhart et al.<sup>43</sup> and Grauer et al.<sup>44</sup> postulate that CBCT may be an effective tool for evaluating the treatment outcome after graft procedures or for long-term monitoring. This is not consistent with our finding that the newly formed bone does not appear in CBCT as radiopaque. Bone substitutes can form a scaffold which allows their colonisation by bone-promoting cells and their replacement by newly formed bone, thus becoming space maintainers in the process.<sup>45</sup> It is interesting to note that this newly formed bone is premature bone and that the resolution of the CBCT scan did not allow the newly formed bone to appear as radiopaque because of its low density. This finding is consistent with our histological results, which found that the newly formed bone has an organised matrix surrounded by an immature bone matrix or osteoid.

After six months, the radiolucency of the NanoBone blocks was evidence that the NanoBone had degraded completely. This is consistent with the finding by Gotz et al.,<sup>46</sup> who postulate that nanocrystalline HA has osteoconductive and biomimetic properties and is integrated into the host's physiological bone turnover at a very early stage. It is also consistent with the findings by Canullo et al.,<sup>19</sup> who stated that newly formed bone, although in limited quantities, was already found at three months of healing and new trabecular bone was found at six months of healing.<sup>20</sup> Conversely, allograft bone did not appear as radiopaque after the augmentation or after six months owing to its composition, so we were unable to determine whether it had degraded completely.

**Figs. 13a & b** Blood flow from posterior area to the flap.



Evaluation of the final treatment was not a part of the present study, but implants were placed in the planned positions and were osseointegrated successfully in eight NanoBone blocks. In addition, implants could not be placed in six patients in groups due to insufficient bone gain. The most important concerns after a bone-block augmentation procedure are the assessment and comparison of the clinical success of the dental implants, which are inserted in the augmented localised atrophied ridges after one year, and determining whether these procedures can prevent resorption of the graft owing to masticatory forces.

**Conclusion**

The use of a NanoBone block resulted in a significant increase in ridge width, facilitating implant placement (Figs. 11a–e) in areas previously judged to be too narrow. The allograft bone block was well tolerated and was associated with a low complication frequency, but was not suitable for ridge augmentation in the posterior mandible. CBCT was not suitable to assess and evaluate bone gain after ridge augmentation by neither Nanobone block nor Fisiograft bone block.

**Recommendation**

Kazanjian vestibuloplasty should be modified by performing only vestibular and mesial vertical incision and not performing distal vertical incision, because distal vertical incision prevents blood flow from posterior area to the flap (Figs. 13a & b). By doing that, blood flow to flap will be from lingual side (a) supplied by the sublingual artery and posterior area (b) supplied by the facial artery and muscular branches of the maxillary artery.

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