


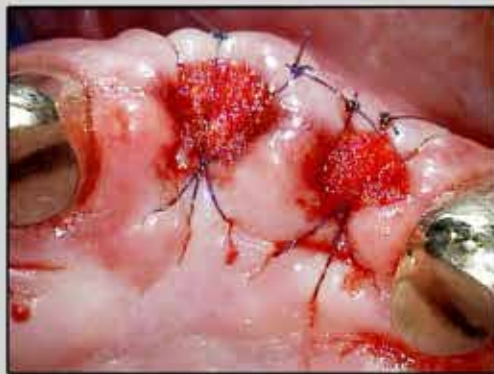
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Comparison of the Effectiveness of Two Different Bone Substitute Materials for Socket Preservation After Tooth Extraction: A Controlled Clinical Study



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The aim of this study was to compare the effectiveness of two bone substitute materials for socket preservation after tooth extraction. Extraction sockets in 10 patients were filled with either inorganic bovine bone material (Bio-Oss) or with synthetic material consisting of hydroxyapatite and silicon dioxide (NanoBone). Extraction sockets without filling served as the control. The results demonstrate the effectiveness of the presented protocol for socket preservation and that the choice of a suitable bone substitute material is crucial. The dimensions of the alveolar ridge were significantly better preserved with Bio-Oss than with NanoBone or without treatment. Bio-Oss treatment resulted in better bone quality and quantity for successful implant placement. (Int J Periodontics Restorative Dent 2013;33:223–228. doi: 10.11607/prd.0734)

Preservation of the dimensions and contour of the alveolar ridge after tooth extraction is of great importance to avoid problems for subsequent implantation or restoration.^{1–6} Numerous studies have confirmed a reduction in the dimensions of the alveolar ridge after tooth extraction.^{1,7–11} In the first 12 months after tooth extraction, the height of the alveolar ridge can diminish by up to 50% because the alveolar bone resorbs, especially on the buccal aspect; approximately two thirds of this resorption takes place in the first 3 months.^{2,3}

Recent clinical studies confirm that by augmenting the extraction socket with bone substitute material, resorption processes are reduced and further treatment steps are simplified.^{4,5} In a dog model, Araújo et al showed that the use of inorganic bovine bone containing 10% collagen (Bio-Oss Collagen, Geistlich) leads to a significant reduction in bone resorption.^{12,13} In a clinical, controlled, randomized study, Nevins et al came to the conclusion that reliable prediction of the success of therapy is not possible after tooth extraction without augmentation of the socket.¹

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The question from the clinical aspect is which bone substitute material is suitable for the indication of socket preservation. Numerous materials are available,¹⁴ and the literature regarding individual materials is diverse. There have been hardly any comparative studies in humans. The present study was therefore conducted to investigate the effectiveness of socket preservation with two different bone substitutes: inorganic bovine bone material (Bio-Oss) and a synthetic bone substitute composed of hydroxyapatite and silicon dioxide (NanoBone, Artoss).

Method and materials

Ten patients (three men, seven women; mean age, 53 years; range, 45 to 67 years) attending a German specialist private practice were included. A total of 32 teeth (at least three teeth per patient) in the maxillary left second premolar to right second premolar region were extracted because of caries and/or failure of endodontic treatment. Minimally invasive extraction was performed as described by Shakibaie-M^{4,5} to spare the socket walls and the peri-alveolar keratinized mucosa. Only completely intact sockets were included in the study (Fig 1a). All patients had unremarkable medical histories and were nonsmokers. One patient did not attend follow-up. Therefore, only data from nine patients were available for analysis.

The extraction sockets were classified into three treatment groups:

- Group 1: The socket was filled with Bio-Oss granules (1 to 2 mm) to the crestal level, compressed slightly (Fig 1b), and covered with a tailored piece of Stypro gelatin sponge (Curasan) (Fig 1c). The wound was sutured using Seralon 5/0 sutures (Serag-Wiessner) (Fig 1d).
- Group 2: The socket was filled with NanoBone (size 1) (Fig 1b). Further procedures were the same as those in group 1.
- Group 3 (control): The socket was filled with Stypro gelatin sponge only and sutured as in the other groups.

One extraction socket in each patient was assigned to study groups 1 and 2, and the remaining sockets to the control group (group 3). The choice of the study and control sockets was left to the patient, with the restriction that the test sockets should be in region 1 to 3 and next to each other and the control sockets should be separated from the study sockets by at least one natural tooth. Patients were informed of the exact procedure, the employed materials, and possible risks at least 2 weeks before the operation. Written informed consent to the operation and to participation in the study was obtained at least 2 days before the operation.

Each patient had at least two natural teeth left in the investigated region, which were used for a provisional telescopic prosthetic restoration. The prosthesis bases were relieved in the region of the investigated sockets to avoid re-

sorption of the bone resulting from pressure points. Implants (diameter, 3.3 to 4.3 mm; Camlog Screw Line, Altatec) were placed after a mean healing period of 12 weeks.

Parameters investigated

The following clinical parameters were measured with an accuracy of 0.5 mm using a periodontal probe: crestal width of the alveolar ridge, measured as the transversal socket diameter, and width of the fixed gingiva, measured vertically from the vestibular edge of the socket margin to the line of the mucogingival border. The alveolar ridge height was determined using single-tooth radiographs taken using the right-angle technique. A sagittal straight line was defined on the radiographs between reference points on the adjacent teeth (cemento-enamel borders and crown margins). This made it possible to determine the vertical distance to the edge of the alveolar border with an accuracy of 0.5 mm. To identify bony and mucosal changes in the alveolar ridge, these parameters were determined both immediately following extraction and 12 to 14 weeks afterward at the time of implantation. The differences were used for analysis.

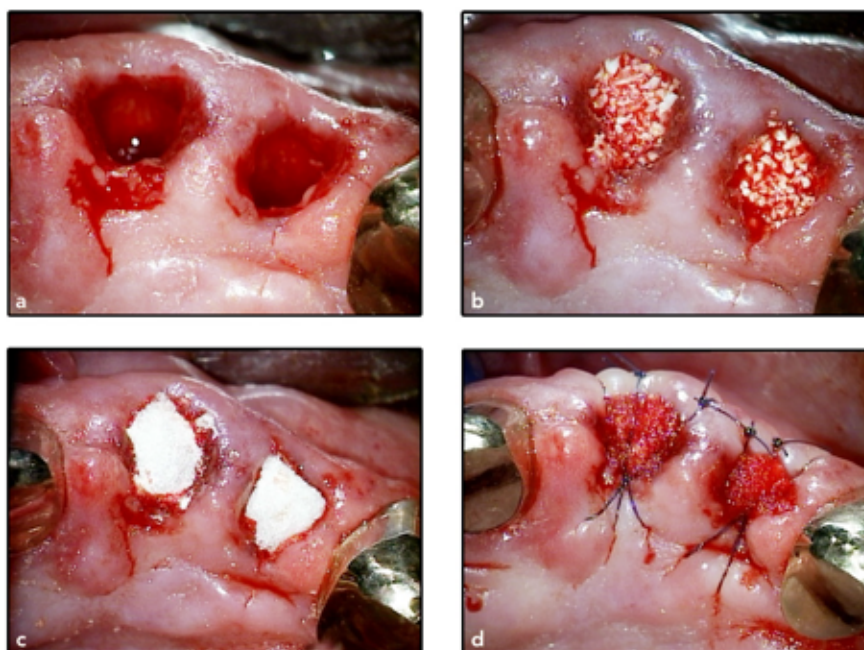
Ten weeks postextraction, three-dimensional digital volume tomography (DVT) was performed. Using coDiagnostiX software (IVS Solutions) the mean local bone density (in Hounsfield units) was determined in the center of the socket as well as the mean transversal and

Fig 1a Surgical procedure in microscopic view (original magnification $\times 14$). Both sockets are completely intact after extraction.

Fig 1b Sockets were filled with bone substitute (right central incisor: Bio-Oss, right lateral incisor: NanoBone).

Fig 1c Sockets covered with Stypro gelatin sponge.

Fig 1d Wound closure was obtained using 5/0 Seralon sutures.



axial alveolar ridge widths (in mm). These parameters were obtained using the measuring module of the coDiagnostiX software with an accuracy of 0.1 mm parallel to the occlusal plane at locations perpendicular to the line of the alveolar ridge, 2 mm apical to the alveolar ridge, and in the center of the former extraction socket, respectively.

Analysis of variance was performed to compare the means of several samples. The means of two unlinked samples were compared using the Student *t* test. SAS/STAT software (SAS Institute) was used for all statistical tests.

Results

All extraction sockets healed without complication (Figs 2a to 2d). On reopening prior to implantation, after 12 to 14 weeks, the gin-

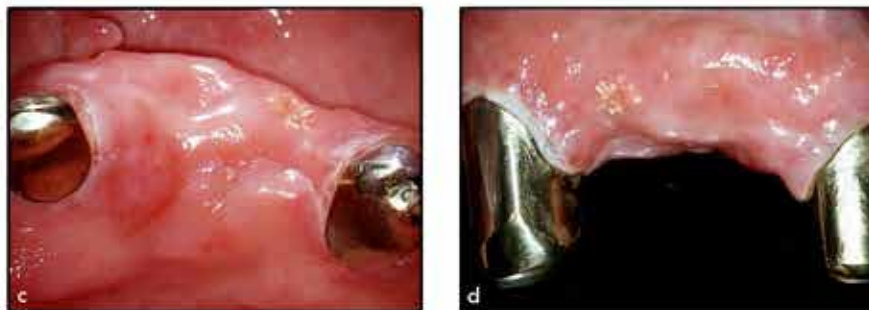
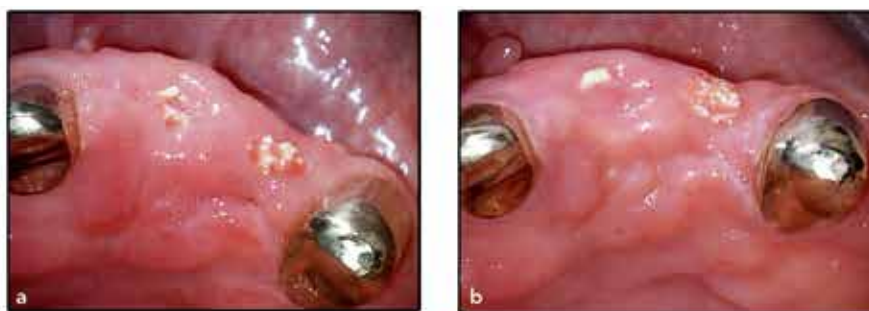
giva was not yet fully keratinized in any of the NanoBone sockets. Crestally, the NanoBone was not integrated in the bone to a mean depth of 3 to 4 mm and had to be removed regularly in the area prior to implant pilot drilling (Fig 3a). In contrast, the Bio-Oss granules were fully integrated in the new bone in seven cases (Fig 3b). In two cases, loose Bio-Oss granules had to be removed to a depth of 1 to 2 mm. In all Bio-Oss sockets, the crestal gingiva was keratinized after 12 weeks without complication and was fully closed (Figs 2c and 2d).

Implant insertion was uneventful in all cases. A total of nine implants with a diameter of 3.8 to 4.3 mm and length of 11 to 13 mm were inserted in the Bio-Oss study group (Figs 4a to 4c). In the NanoBone study group, only five implants with a diameter of 3.3 to 3.8 mm and length of 9 to 11 mm

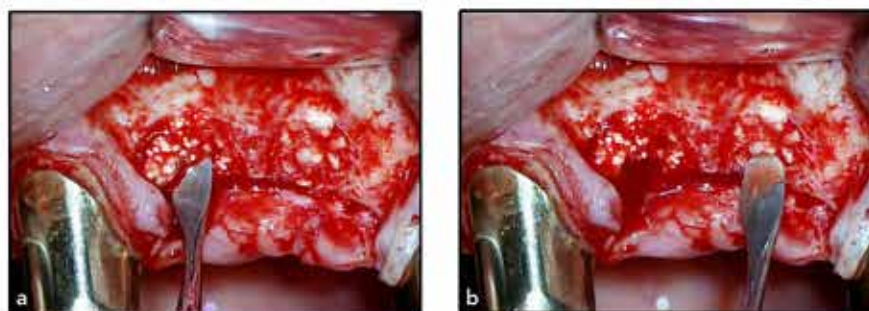
could be placed because of the resorption processes at the alveolar ridge (Figs 4a to 4c). In the control group, implantation without additional augmentation was possible in only three cases (implant diameter, 3.3 to 3.8 mm; length, 9 to 11 mm).

Bone density in the control group (352 ± 29.3 HU) and the NanoBone group (399 ± 15.6 HU) was lower than that in the Bio-Oss group (699 ± 13.3 HU; $P < .001$), which was also apparent in the mean primary stability values of the inserted implants (control and NanoBone, 20 Ncm; Bio-Oss, 30 Ncm).

Before treatment, no differences were found between treatment groups for the parameters mean crestal alveolar ridge width, mean width of the fixed gingiva, and mean alveolar ridge height ($P > .10$). The variables were dis-



Figs 2a to 2d Uncomplicated healing of the augmented extraction sockets at (a) 4, (b) 8, and (c and d) 12 weeks after extraction. The decreased three-dimensional volume at the lateral incisor (NanoBone) compared with the central incisor (Bio-Oss) is clearly visible. The absence of gingival healing and keratinization of the soft tissue crestally at the lateral incisor site after 12 weeks is also noteworthy.



Figs 3a and 3b Extraction sockets after reopening for implant insertion 12 weeks after extraction and socket preservation. (a) The NanoBone granules were not integrated in the new bone crestally to a depth of up to 3 to 4 mm, while (b) Bio-Oss was completely integrated.

tributed normally. A reduction of the crestal width and height of the alveolar ridge as well as the width of the fixed gingiva was observed in all groups, but it differed highly significantly depending on the treatment (Fig 5; $P < .01$ for all parameters). The smallest decrease was observed in extraction sockets treated with Bio-Oss. The lower alveolar ridge height and width that was observed in the NanoBone group had a detri-

mental effect on the subsequent implant positioning (Figs 4b and 4c). These differences were also clearly visible in the DVT images (Fig 6). The variables of the parameters recorded by means of three-dimensional DVT were distributed normally. It was apparent that the mean transversal and axial alveolar ridge widths in extraction sockets that had been filled with Bio-Oss (transversal, 6.67 ± 0.86 mm; axial, 6.44 ± 0.87 mm) were significant-

ly greater 10 weeks after extraction than those in control sockets (transversal, 4.45 ± 0.72 mm; axial, 4.30 ± 0.86 mm; $P < .001$ and $P < .01$, respectively). Both parameters were also significantly greater in the Bio-Oss group than in the NanoBone group (transversal, 5.39 ± 0.85 mm; axial, 5.17 ± 0.90 mm; both $P < .05$). A significant difference between the NanoBone group and the control group was not observed.



Fig 4a Crestal view after final preparation of the implant beds.



Fig 4b Implant insertion. Frontal view immediately after insertion illustrates the lower alveolar ridge height in the right lateral incisor site (NanoBone).



Fig 4c Insertion of a Camlog Screw Line implant (3.8 mm diameter, 11 mm long) at the central incisor site and a Camlog Screw Line implant (3.3 mm diameter, 11 mm long) at the lateral incisor site. The inadequate alveolar ridge width at the lateral incisor should be noted, which led to a palatal bone thickness of only 0.2 mm after implant insertion.

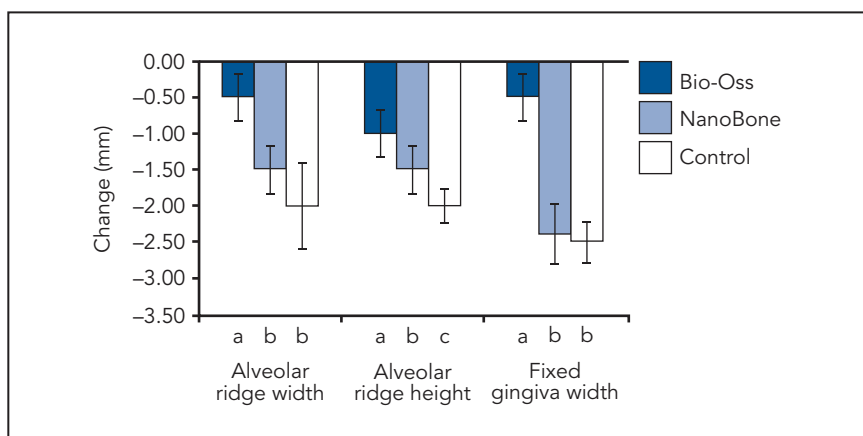


Fig 5 Reduction of the crestal width, height of the alveolar ridge, and width of the fixed gingiva 12 to 14 weeks after tooth extraction in the three study groups (means \pm 95% confidence intervals). Different letters indicate significant differences within parameters at the $P < .05$ level.

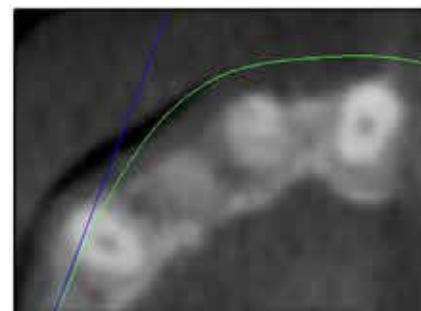


Fig 6 DVT axial view 1 week before implantation shows the higher degree of horizontal resorption at the lateral incisor (NanoBone) compared with the central incisor (Bio-Oss).

Discussion

It is crucial to preserve the dimensions of the alveolar ridge after tooth extraction to achieve a predictable esthetic and functional prosthetic restoration. The efficacy of socket preservation has been shown in several clinical^{1,4,15} and preclinical studies^{12,13} and was confirmed in this study. The dimensions of the alveolar ridge were largely preserved both horizontally

and vertically 12 weeks after extraction, as were the dimensions of the keratinized gingiva. Moreover, with Bio-Oss, the bone density in the extraction socket was significantly greater 10 weeks after extraction than in the control and NanoBone groups, probably resulting from the presence of Bio-Oss granules not yet absorbed after 10 weeks.

This study shows that a suitable bone substitute must be selected

to preserve the dimensions of the alveolar ridge. With regard to the indication of socket preservation, the xenogenic bone substitute Bio-Oss was clearly superior to the synthetic bone substitute NanoBone. Many of the parameters did not differ or differed slightly between the control and NanoBone groups. Although NanoBone has been shown to be effective in sinus augmentation procedures,^{16,17} it is not suitable for the indication of

socket preservation. Socket preservation deals with a special defect configuration that is partially exposed in the mouth and makes different demands of the augmentation material than in the case of closed defects. Furthermore, the slow resorbability and long-term stability of Bio-Oss appears to be an advantage for preserving alveolar ridge structures.

In the group treated with Bio-Oss, the alveolar ridge width and height and the width of the fixed gingiva decreased slightly but significantly less than in the control and NanoBone groups. Similar observations have been made in other studies. For example, Nevins et al¹ showed a decrease of the alveolar ridge of 2.42 mm with Bio-Oss and 5.24 mm in the control group 3 months after extraction of teeth with prominent roots in the anterior region; the difference was significant. These data demonstrate that bone resorption cannot be completely prevented even with effective socket preservation. However, the current data, as well as data from Nevins et al,¹ Artzi and Nemcovsky,¹⁵ and Irinakis and Tabesh,¹⁸ demonstrate that the dimensions of the alveolar ridge and keratinized soft tissue can be preserved to a major extent by socket preservation with Bio-Oss so that an optimal future implant site can be created predictably.

Conclusions

This comparative study confirmed the effectiveness of socket preserva-

tion after tooth extraction. Without treatment of the extraction socket with suitable materials, marked three-dimensional bone loss and a reduction in the quantity and quality of keratinized gingiva take place. Moreover, this study showed that the choice of a suitable bone substitute for socket preservation is crucial for the success of treatment. With regard to the results presented, Bio-Oss appears to be more suitable for socket preservation than NanoBone.

Acknowledgments

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