Interventions for replacing missing teeth: augmentation procedures of the maxillary sinus.


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Abstract

BACKGROUND: Insufficient bone volume is a common problem encountered in the rehabilitation of the edentulous posterior maxillae with implant-supported prostheses. Bone volume is limited by the presence of the maxillary sinus together with loss of alveolar bone height. Sinus lift procedures increase bone volume by augmenting the sinus cavity with autogenous bone and/or commercially available biomaterials.

OBJECTIVES: To determine whether and when augmentation of the maxillary sinus are necessary and which are the most effective augmentation techniques for rehabilitating patients with implant-supported prostheses.

SEARCH STRATEGY: The Cochrane Oral Health Group's Trials Register, CENTRAL, MEDLINE and EMBASE were searched on 7th January 2010. Several dental journals were handsearched. The bibliographies of review articles were checked, and personal references were searched. More than 55 implant manufacturing companies were also contacted.

SELECTION CRITERIA: Randomised controlled trials (RCTs) of different techniques and materials for augmenting the maxillary sinus for rehabilitation with dental implants reporting the outcome of implant success/failure at least to abutment connection.

DATA COLLECTION AND ANALYSIS: Screening of eligible studies, assessment of the methodological quality of the trials and data extraction were conducted independently and in duplicate. Authors were contacted for any missing information. Results were expressed as random-effects models using mean differences for continuous outcomes and odds ratios for dichotomous outcomes with 95% confidence intervals. The statistical unit of the analysis was the patient.

MAIN RESULTS: Ten RCTs out of 29 met the inclusion criteria. One trial of 15 patients evaluated implants 5 mm long with 6 mm diameter as an alternative to sinus lift in bone with a residual height of 4 to 6 mm. Nine trials with 235 patients compared different sinus lift techniques; of these four trials (114 patients) evaluated the efficacy of platelet-rich plasma (PRP). Due to the variety of techniques evaluated, meta-analysis was only possible of use of PRP for implant failure (two trials) and complications (three trials). No statistically significant difference was observed.
AUTHORS’ CONCLUSIONS: Conclusions are based on few small trials, with short follow-up, and judged to be at high risk of bias. Therefore conclusions should be viewed as preliminary and interpreted with great caution. It is still unclear when sinus lift procedures are needed. 5 mm short implants can be successfully loaded in maxillary bone with a residual height of 4 to 6 mm but their long-term prognosis is unknown. Elevating the sinus lining in presence of 1 to 5 mm of residual bone height without the addition of a bone graft may be sufficient to regenerate new bone to allow rehabilitation with implant-supported prostheses. Bone substitutes might be successfully used as replacements for autogenous bone. If the residual alveolar bone height is 3 to 6 mm a crestal approach to lift the sinus lining, to place 8 mm implants may lead to fewer complications than a lateral window approach, to place implants at least 10 mm long. There is no evidence that PRP treatment improves the clinical outcome of sinus lift procedures with autogenous bone or bone substitutes.

The use of Straumann Bone Ceramic in a maxillary sinus floor elevation procedure: a clinical, radiological, histological and histomorphometric evaluation with a 6-month healing period.

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Abstract

OBJECTIVES: In this study, we evaluated the quality and quantity of bone formation in maxillary sinus floor elevation procedure using a new fully synthetic biphasic calcium phosphate (BCP) consisting of a mixture of 60% hydroxyapatite and 40% of beta-tricalcium phosphate (Straumann Bone Ceramic).

MATERIAL AND METHODS: A unilateral maxillary sinus floor elevation procedure was performed in six patients using 100% BCP. Biopsy retrieval for histological and histomorphometric analysis was carried out before implant placement after a 6-month healing period.

RESULTS: In this study, the maxillary sinus floor elevation procedure with the use of BCP showed uneventful healing. Radiological evaluation after 6 months showed maintenance of vertical height gained immediately after surgery. Primary stability was achieved with all Straumann SLA dental implants of 4.1 mm diameter and 10 or 12 mm length. The implants appeared to be osseointegrated well after a 3-month healing period. Histological investigation showed no signs of inflammation. Cranial from the native alveolar bone, newly formed mineralized tissue was observed. Also, osteoid islands as well as connective tissue were seen around the BCP particles, cranial from the front of newly formed mineralized tissue. Close bone-to-substitute contact was observed. Histomorphometric analysis showed an average bone volume/total volume (BV/TV) of 27.3% [standard deviation (SD) 4.9], bone surface/total volume (BS/TV) 4.5 mm(2)/mm(3) (SD 1.1), trabecula-thickness (TbTh) 132.1
mum (SD 38.4), osteoid-volume/bone volume (OV/BV) 7.5% (SD 4.3), osteoid surface/bone surface (OS/BS) 41.3% (SD 28.5), osteoid thickness (O.Th) 13.3 mum (SD 4.7) and number of osteoclasts/total area (N.Oc/Tar) 4.4 1/mm (SD 5.7).

CONCLUSIONS: Although a small number of patients were treated, this study provides radiological and histological evidence in humans confirming the suitability of this new BCP for vertical augmentation of the atrophied maxilla by means of a maxillary sinus floor elevation procedure allowing subsequent dental implant placement after a 6-month healing period. The newly formed bone had a trabecular structure and was in intimate contact with the substitute material, outlining the osteoconductive properties of the BCP material. Bone maturation was evident by the presence of lamellar bone.

**Maxillary sinus grafting with Bio-Oss or Straumann Bone Ceramic: histomorphometric results from a randomized controlled multicenter clinical trial.**


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**Abstract**

**INTRODUCTION:** This investigation was designed to compare the histomorphometric results from sinus floor augmentation with anorganic bovine bone (ABB) and a new biphasic calcium phosphate, Straumann Bone Ceramic (BCP).

**MATERIALS AND METHODS:** Forty-eight maxillary sinuses were treated in 37 patients. Residual bone width was > or =6 mm and height was > or =3 mm and <8 mm. Lateral sinus augmentation was used, with grafting using either ABB (control group; 23 sinuses) or BCP (test group; 25 sinuses); sites were randomly assigned to the control or test groups. After 180-240 days of healing, implant sites were created and biopsies taken for histological and histomorphometric analyses. The parameters assessed were (1) area fraction of new bone, soft tissue, and graft substitute material in the grafted region; (2) area fraction of bone and soft tissue components in the residual alveolar ridge compartment; and (3) the percentage of surface contact between the graft substitute material and new bone.

**RESULTS:** Measurable biopsies were available from 56% of the test and 81.8% of the control sites. Histology showed close contact between new bone and graft particles for both groups, with no significant differences in the amount of mineralized bone (21.6+/-10.0% for BCP vs. 19.8+/-7.9% for ABB; P=0.53) in the biopsy treatment compartment of test and control site. The bone-to-graft contact was found to be significantly greater for ABB (48.2+/-12.9% vs. 34.0+/-14.0% for BCP). Significantly less remaining percentage of graft substitute material was found in the BCP group (26.6+/-5.2% vs. 37.7+/-8.5% for ABB; P=0.001), with more soft tissue components (46.4+/-7.7% vs. 40.4+/-7.3% for ABB; P=0.07). However, the amount of soft tissue components for both groups was found not to be greater than in the residual alveolar ridge.
DISCUSSION: Both ABB and BCP produced similar amounts of newly formed bone, with similar histologic appearance, indicating that both materials are suitable for sinus augmentation for the placement of dental implants. The potential clinical relevance of more soft tissue components and different resorption characteristics of BCP requires further investigation.

**Use of cell-based approaches in maxillary sinus augmentation procedures.**

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**Abstract**

The dimension of alveolar ridge is decreased by bone atrophy and pneumatization of the maxillary sinus after loss of teeth in the posterior maxilla, and sinus augmentation procedures are performed to create bone quantity and quality to ensure the placement of dental implants. Various osteoconductive materials have been used to augment the sinus floor, but these materials are cell-free and require more time for bone healing. Attempts have been made to apply a cell-based approach that uses mesenchymal stem cells combined with an osteoconductive scaffold. Adult stem cells that can be derived from various tissues including bone marrow, periosteum, and trabecular bone have been applied in sinus augmentation procedures both experimentally and clinically with successful results. In this review, the cell-based approaches in sinus augmentation procedures with various carriers will be described and the efficacy and clinical applicability will be addressed.

**Histologic and clinical evaluation for maxillary sinus augmentation using macroporous biphasic calcium phosphate in human.**

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**Abstract**

OBJECTIVES: This study evaluated both the clinical and histological aspects of bone formation in maxillary sinus augmentation using MBCP as the bone-grafting material.

MATERIAL AND METHODS: MBCP was used as a primary bone substitute for maxillary sinus augmentation. Fifty-two patients were selected after a medical and dental examination, and were divided into the following three groups: those augmented with MBCP only; MBCP combined with irradiated cancellous bone; and MBCP combined with intraoral autogenous bone. After a healing period (average 6.78 months after surgery), bone cores were harvested.
for a histological evaluation and the implant fixtures were installed. These bone cores were evaluated via light microscope and implants were followed up for at least six months after loading.

RESULTS: Four to ten months after surgery, new vital bone surrounding the MBCP particles was observed in 18 bone biopsies. Two out of the 130 implants installed were explanted due to a failure of osseointegration before the prosthetic procedure. All the remaining implants were functioning for 6 to 27 months (average 12.96 months). The cumulative survival rate of the implants was 98.46%.

CONCLUSION: These results show that MBCP can be used as a grafting material for sinus floor augmentation, whether combined with other bone graft materials or not, and lead to a predictable prognosis for dental implants in the posterior maxillary area where there is insufficient vertical height for fixture installation.

Long-term changes in graft height after maxillary sinus floor elevation with different grafting materials: radiographic evaluation with a minimum follow-up of 4.5 years.

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Abstract

OBJECTIVE: To compare the vertical dimensional changes with regard to graft height in a long-term follow-up in patients treated with two different grafting materials used in maxillary sinus floor elevation procedures.

MATERIAL AND METHODS: Twenty consecutive patients were included. One group was grafted with autogenous bone from the mandible (chin area), and the other group was augmented with a 100% beta-tricalcium phosphate (beta-TCP). During a 4- to 5-year period, in each patient, at least five panoramic radiographs were made. These panoramic radiographs were used for morphometric measurements, at three different locations. The three locations were the first bone to implant contact at the distal side of the second most posterior implant (L1), halfway between this implant and the most posterior implant (L2) and the site 5 mm distal to the most posterior implant (L3). The measured vertical bone heights were evaluated to assess whether there was loss of height and, if so, whether the reduction in graft height occurred in an initial healing period or whether it was an ongoing process during the whole study period.

RESULTS: There is a statistically significant reduction of vertical bone height in time at all locations (P<0.001). The mean decrease of the total vertical height during the whole study period at the three different locations did not differ significantly for and between both grafting groups. Repeated measures analysis of variance showed that at location L1, the reduction in millimeters per month decreased in time (P=0.001). There was no difference between the
grafting groups (P=0.958). Similar results were found on L2 (P=0.005). For L3, there also appeared to be a statistically significant difference in reduction in time in millimeters per month (P=0.004). There was no statistically significant difference in height reduction between locations L1, L2 and L3 for vertical bone height and graft height, respectively.

CONCLUSIONS: Both beta-TCP and mandibular bone grafts resulted in radiographic reduction of the vertical height over the 5-year period following maxillary sinus floor elevation. After an initial height reduction in the first 1.5 year, subsequent changes were minimal. No significant differences were observed between the two types of grafting material. There was no statistically significant difference in reduction between the three locations for vertical bone height and graft height, respectively.

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Abstract

Purpose: Although many studies have analyzed the suitability of different grafting materials for maxillary sinus augmentation by means of histomorphometry in conventional histologic stains, the three-dimensional (3D) structure and remodeling of these grafts after healing beneath the sinus membrane remain unclear. The aim of the present study was to determine whether microcomputed tomography is a suitable method to evaluate the 3D structure and remodeling of grafts after sinus floor augmentation. Materials and Methods: Sinus floor augmentation was performed in five patients using autogenous bone (AB) alone, AB and beta-tricalcium phosphate (b-TCP, Cerasorb), AB and b TCP/hydroxyapatite (HA) (BoneCeramic), AB and calcium carbonate (Algipore), and AB and HA (PepGen). Specimens from the grafted sites were harvested by means of a trephine bur 5 to 16 months after maxillary sinus augmentation. Microcomputed tomography of these specimens was performed with a nominal isotropic resolution of 6 3 6 3 6 Mm2 voxel size. After segmentation, 3D images were reconstructed, and the distribution of bone and substitute material was evaluated by means of volumetric and density measurements. Results: In all images, both bone and substitute material could clearly be identified. The connectivity of trabeculae surrounding the substitute material was visible in the 3D reconstructions. Volumetric evaluation such as total bone volume, volume of substitute material, and trabecular thickness and spacing revealed differences between the different grafting materials. Conclusion: Microcomputed tomography is a promising method to evaluate the 3D structure of grafts after sinus floor augmentation with autogenous bone and bone substitute materials. Int J Oral Maxillofac Implants 2010;25:930-938.

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Histomorphometric comparison of a biphasic bone ceramic to anorganic bovine bone for sinus augmentation: 6- to 8-month postsurgical assessment of vital bone formation. A pilot study.
Abstract

This blinded, randomized, controlled pilot investigation is the first to histomorphometrically compare vital bone formation following bilateral sinus grafting with a biphasic calcium phosphate (BCP) (Straumann Bone Ceramic) to an anorganic bovine bone matrix (ABBM) (Bio-Oss) 6 to 8 months following graft placement. Twelve patients were selected. Following elevation of the lateral sinus walls, one material was placed in the right sinus and the other material was placed in the left sinus, as determined by randomization. Six to 8 months after grafting (with the same time frame used for each patient), a trephine core was taken from the grafted area and sent for histomorphometric analysis. Cores were obtained from 21 healed sinuses in 12 patients. Nine patients provided bilateral cores. Histomorphometric analysis of 10 BCP cores and 11 ABBM cores revealed an average vital bone content of 28.35% and 22.27%, respectively. The average percentage of residual graft particles was 28.4% in the BCP cores and 26.0% in the ABBM cores. The difference in vital bone formation was not significantly different (n = 9 patients, paired t test) between bilateral sinuses treated with the BCP and those treated with the ABBM. Histologically, both materials appeared to be osteoconductive and support new bone formation. Future studies are needed to confirm the ability of this regenerated bone to support dental implant maintenance over time.
RESULTS: Twenty-one articles were included in the review. The highest level of evidence consisted of prospective cohort studies. A descriptive analysis of the constructed evidence tables indicated that the type of graft did not seem to be associated with the success of the procedure, its complications, or implant survival. Length of healing period, simultaneous implant placement or a staged approach or the height of the residual alveolar crest, sinusitis or graft loss did not modify the lack of effect of graft material on the outcomes. Three studies documented that there was donor site morbidity present after the harvest of AB. When iliac crest bone was harvested this sometimes required hospitalization and surgery under general anesthesia. Moreover, bone harvest extended the operating time. The assessment of disease transmission by BS was not a topic of any of the included articles.

DISCUSSION AND CONCLUSION: The retrieved evidence provides a low level of support for selection of AB or a bone substitute. Clear reasons could not be identified that should prompt the clinician to prefer AB or BS.

Ridge augmentation and maxillary sinus grafting with a biphasic calcium phosphate: histologic and histomorphometric observations.

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Abstract

OBJECTIVES: This retrospective study reports on histologic and histomorphometric observations performed on human biopsies harvested from sites augmented exclusively by biphasic calcium phosphate [BCP: hydroxyapatite (HA)/ tricalcium phosphate (TCP) 60/40] and healed for a minimum of 6 months.

MATERIALS AND METHODS: Five patients benefited from three augmentation regimens (i.e.: one-stage lateral augmentation; two-stage lateral augmentation; and two-stage sinus grafting). In all patients, a degradable collagen membrane served as a cell-occlusive barrier. Core biopsies were obtained from lateral as from crestal aspects 6-10 months after augmentation surgeries. For histologic and histomorphometric evaluations, the non-decalcified tissue processing was performed.

RESULTS: The histological examination of 11 biopsies showed graft particles frequently being bridged by the new bone, and a close contact between the graft particles and newly formed bone was seen in all samples. The mean percentages of newly formed bone, soft tissue compartment, and graft material were 38.8% (+/-5.89%), 41.75% (+/-6.08%), and 19.63% (+/-4.85%), respectively. Regarding bone-to-graft contact values, the percentage of bone coverage of graft particles for all biopsies ranged from 27.83% to 80.17%. The mean percentage of bone coverage was 55.39% (+/-13.03%).

CONCLUSIONS: Data from the present study demonstrated osteoconductivity scores for the BCP material (HA/TCP 60/40) in patients resembling those previously shown for grafting materials of xenogenic and alloplastic origin.