A clinical comparison

β-tricalcium phosphate vs hydroxyapatite ceramics

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The topic of bone substitution or bone regeneration, xenografts, allografts or biomimetic materials are discussed very controversially in the OMF surgery at times. However, the progress and good clinical experiences made with biomimetic materials during the last two decades are undisputed. The present observational study compares two established bone augmentation materials of different chemistry and structure in a direct, indication-related way. The mentioned study cases show that both material types are able to support the surgical work substantially, considering the respective task.

The essential questions related to the product group of the biomimetic materials are about the structure preserving its volume without resorption, or complete degradation of the applied material. The restructuring into vital new bone tissue holds the inevitable side effect of a controlled, yet existing volume loss. The materials used for the comparison are manufactured and distributed by the company curasan (Kleinostheim, Germany) under the names CERASORB® M and Osbone®. CERASORB® M is a β-tricalcium phosphate (β-TCP) with a phase purity of 99 % in spongy, polygonal broken form. The open-celled structure with interconnected micro-, meso- and macropores allows a fast ingrowth of osteoblasts and a complete transformation into new vital bone tissue. Due to the lack of any biological and organic content the material can be safely used. The manufacturing process guarantees complete sterility and absence of pyrogens. Osbone® is a purely biomimetic hydroxyapatite with a porosity of 80 % and a likewise polygonal broken granular form with interconnected pores. This leads to a very spongy-like structure of the product. The hydroxyapatite is resorbed extremely slow and therefore guarantees a high volume stability over time and early mechanical endurance.

Both products have a clear advantage over xenogeneic materials with the early osteoblastic colonisation and therefore an early bone formation, as the examination of Bernard A. et al. of 2010 shows (Figs. 1a–c). Further important parameters for the evaluation of bone augmentation and bone regeneration materials are:

- **Primary particle size**
  A bone augmentation material with a particle size higher than 10 µm is ideal to avoid cellular decomposition and phagocytosis. It ensures the mechanical stability of the fabric as well as the interconnecting microporosity. A particle size of less than 10 µm stimulates the phagocytosis by macrophages. This leads to an unwanted and premature loss of the bone augmentation material in the defect and a complete biological bone regeneration cannot take place.

- **Scaffold stability**
  The granules must not dissolve and disintegrate into small particles or lose stability due to the solution process when the product is applied. A premature disintegration into microparticles provokes an activity of phagocytizing macrophages and polymorphic polynuclear cells. Thereby increased unspecific immunoreaction interferes with the regeneration process. In some cases this can lead to an exuberant inflammatory reaction.
Interconnecting, spongy–open–celled pore structure and continuous structuring with blood vessels

Pores increase the surface and are vascularised in case of sufficient diameter. The pore diameter should at least be 100 µm for the ingrowth of vascularised, mineralised tissue. This enables a complete structuring. The pore size of the synthetic hydroxyapatite is mostly between 250 and 450 µm which supports vascularisation and osseointegration.

Biocompatibility

28 days after the beginning of the cell cultivation, a very good cellular proliferation is clearly visible in the wide extension and clustering of the osteoblasts on Osbone®. The biocompatibility of the bone augmentation material is already visible in vitro, due to good cell population properties. Due to its high similarity to a natural bone form, the hydroxyapatite could be confirmed to have a very good biocompatibility. Comparisons of in vitro studies with an osteoblast cell line show the reliable, very good cell population properties.

Case studies—indications and usage

Both of the two described products are qualified for the treatment and reconstruction of complex three-dimensional bone defects. However, after extirpation of cysts, size, localisation, cyst-type and the age of the patient play a major role as well. The β-TCP (CERASORB® M) is preferred because the goal is a complete regeneration from defect to the natural bone tissue (Figs. 2a–c).

Filling of bone defects

A 9-year-old patient came with an extensive follicular cyst in the region 23. Due to an extensive cyst growth, a massive bone resorption of the maxillary bone was noticed. The cyst growth completely decomposed the alveolar ridge bone up to the maxillary sinus (Fig. 3). After removal of the retained and extremely displaced tooth 23 (Fig. 4) as well as extirpation of the cyst and the surrounding tissue, a considerable bone defect remained (Fig. 5). The β-TCP was mixed with blood from the defect and applied without pressure (Fig. 6). Additionally, the graft material was covered with a resorbable membrane. The postoperative radiograph after six months (Fig. 7) and after six years (Fig. 8) shows a perfect bone regeneration in the treated area. This creates a foundation for a good future for implantological treatment after the bone maturity is complete.
Reconstruction of a lateral wall

A 52-year-old patient had a follicular cyst in region 23 with a retained and displaced tooth 23 (Fig. 9). Because the patient wanted to replace the gap with an implant later on, a ridge preservation had to be performed. After osteotomy of tooth 23 and cystectomy an extensive bone defect was visible, with a missing vestibular wall. The cover and reconstruction of the vestibular bone was done with resorbable (PDLLA) pins and a resorbable (PDLLA) membrane. This created a possibility to fill the defect with β-TCP granules soaked in blood (Figs. 10 & 11). Afterwards, the wound was closed with interrupted sutures (Fig. 12). The postoperative panoramic scan shows the filling of the defect radiographically (Fig. 13).

Augmentation of atrophied maxillary ridge

Both materials are suitable for the internal and external sinus floor elevation, however β-TCP is preferred for sinus lift procedures. When the bone defect is vestibular or the bone quality is poor, the application of hydroxyapatite is more advantageous.

A 65-year-old patient presented with an extensive maxillary bone atrophy with loss of the teeth #14 to #16, #21, #22, #36 and #46 (Fig. 14). Firstly, a 3-D CT presentation of the jaws was made to determine the necessary bone augmentation. Afterwards, a sinus floor elevation on the right side was performed by means of balloon lifting technique. A sinus floor augmentation with combination of β-tricalcium phosphate and autologous bone was performed on the right side. Simultaneously, three implants were placed in the first quadrant with the help of a prefabricated guided-implant surgery template (Fig. 15).

In the second quadrant, a massive lateral bone augmentation had to be performed, otherwise, the implants in the vestibular cranial direction would not have been covered by bone tissue. For prosthetic reasons, no other position could be chosen for the implants. After implant insertion with CT templates in region 21 and 22, the lateral bone augmentation was effected with a compound of β-TCP and autologous bone and a resorbable membrane was used for coverage (Fig. 16).
A simultaneous implant insertion was performed in the third and fourth quadrant in region 36 and 46 (Fig. 17). After a six-month healing phase, the implants were exposed and a prosthetic solution was fabricated (Fig. 18).

Summary

Today, different bone grafting materials with different properties and approaches are available for preservation, augmentation and reconstruction of the dental bone ridge. The systematic purpose of this study was to compare CERASORB® M and Osbone®. The products were evaluated regarding their chemical and biological properties and the following clinical applications:

1. Filling and reconstruction of complex three-dimensional bone defects.
2. Ridge augmentation in atrophied bone regions (sinus floor elevation and subantral augmentation).
3. Filling of alveolar defects after tooth extraction for the purpose of alveolar ridge preservation and creation of an implant bed, or filling of defects after operative removal of retained teeth—as well as corrective osteotomies or multisided bone defects of the alveolar processes and the facial skull.
4. Filling of two- or multisided bone pockets and bi- as well as trifurcation defects.
5. Supporting function for a membrane with the Guided Tissue Regeneration (GTR).

The comparison showed the following results:

Both materials are of biomimetic origin and therefore free of foreign materials or allergens. A good biocompatibility is guaranteed by the interconnecting, open-celled and porous structure. The β-TCP offers advantages for cyst defect filling, as the goal is a physiological bone regeneration. Both materials are suitable for the sinus lift; however, the thickness of the Schneiderian Membrane has to be considered. If the membrane is thin, β-TCP has to be applied because of its polygonal structure.

The hydroxyapatite should be preferred for lateral bone augmentation. In case of poor bone quality (D3/D4) and/or two-sided procedure, the hydroxyapatite should also be used due to its higher volume stability. CERASORB® M should be preferred for the filling of alveolar defects without a subsequent implant insertion or for single tooth defects; Osbone® should be chosen for multisided defects. For the purpose of two- or multisided bone pockets as well as bi- and trifurcation defects, and for the supporting function of a membrane both materials are suitable. Because of its constant volume, the hydroxyapatite should be preferred for vertical and lateral augmentation as well as for peri-implantitis.

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