
FAQ
requently asked uestions
maxresorb®
botiss
biomaterials

What is maxresorb® composed of?

maxresorb® is a synthetic product with a biphasic composition of 60% hydroxyapatite (HA) and 40% beta-tricalcium phosphate (β-TCP), which are two of the most used calcium phosphates. Both components differ in their dissolution and cellular degradation properties. By combining HA and β-TCP a product with specific, beneficial resorption characteristics can be gained. (see next question).

Hydroxyapatite (HA)

$Ca_{10}(PO_4)_6(OH)_2$

Beta-tricalcium phosphate (β-TCP)

$Ca_3(PO_4)_2$

What are the advantages of calcium phosphate-based materials?

Calcium phosphate (CaP)-based biomaterials have been used in regenerative dental medicine for more than 40 years. Because of their similarity to the mineral phase of bone and teeth, synthetically produced calcium phosphate ceramics are characterized by an excellent biocompatibility.

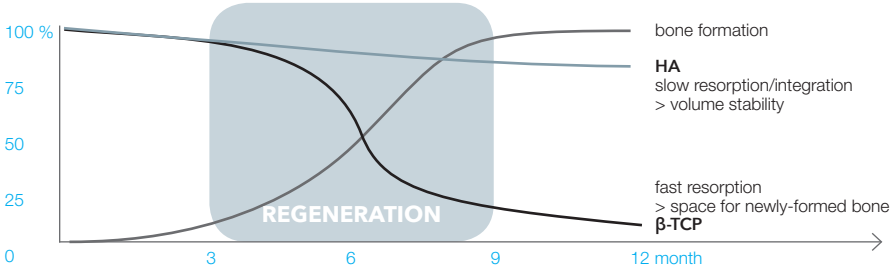
In particular, the advantages of these calcium phosphates lie in their bioactive and remodeling properties, which support the attachment and proliferation of bone cells. Degradation of CaP-implants occurs by dissolution, but they are also subject to osteoclastic resorption, thus are involved into the natural bone remodeling process.

What is the advantage of a biphasic material compared to pure β-TCP or pure HA?

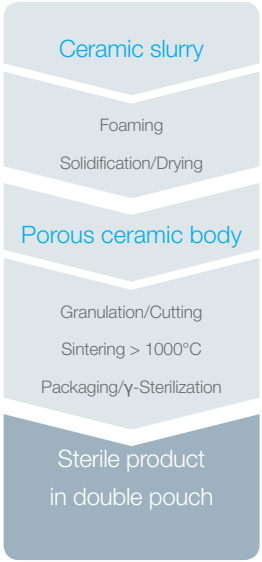
An ideal bone regeneration material should resorb in the same rate in which new bone is formed. The basic principle of maxresorb® is to achieve a balance between the resorption properties of hydroxyapatite (HA), and β-tricalcium phosphate (β-TCP).

Pure β-TCP resorbs quite fast due to high solubility and therefore, may not offer sufficient volume stability for larger augmentative procedures. On the other hand, pure synthetic HA resorbs very slowly and some studies have demonstrated the inferior osteoconductivity of synthetically produced HA when used alone[1].

By mixing HA and β-TCP the advantages of both materials are combined to achieve a material with good osteoconductive as well as resorption properties. Studies have shown that the optimal HA/β-TCP ratio lies between 65:35 and 55:45[2,3].



How is maxresorb® manufactured?



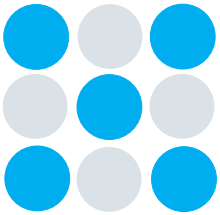
For the unique production process a ceramic slurry is prepared of the powders of hydroxyapatite and β-tricalcium phosphate. The slurry is mixed to homogenous consistency and foamed to introduce pores. Later on, the composite is dried to a porous ceramic body and then granulated, heated and sterilized. As both phases are equally distributed within the final material, the volume of the material and the augmented site can be maintained in course of the resorption process. The β-TCP component resorbs faster, thus gradually increasing porosity, while the HA component stays longer giving the structural support.

What does homogenous composition mean?

maxresorb® shows a homogenous distribution of the two phases HA and β-TCP. **Meaning, the product is not manufactured by only mixing HA and β-TCP granules, but by a synthesis-based process resulting in an equal distribution of both phases in each granule.**

Homogeneous bi-phasic mixture of HA and β-TCP

VS.



Mixture of HA and β-TCP granules

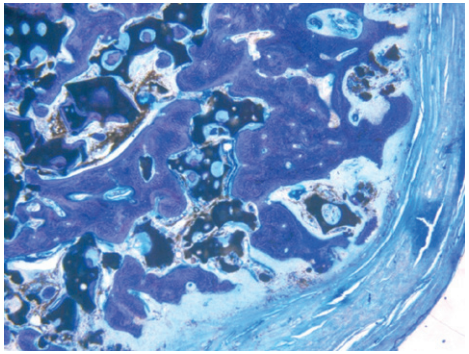
What happens with the material after implantation?

When can the re-entry be performed following augmentation with maxresorb®?

maxresorb® exhibits a controlled remodeling within about 2 to 3 years.

Following implantation, the particles are first integrated into the forming bone, comparable to cerabone®, but then are gradually remodeled. The β-TCP component remodels within 3-6 months while the HA component resorbs much slower within >2 years.

Although clinical results demonstrate a somewhat faster regeneration of defects treated with maxresorb®, it is recommended to follow the same treatment protocol as for bovine materials. **Accordingly, re-entry after ridge augmentation or sinus lift procedures with maxresorb® should be performed 6 to 9 months post-operatively.** This time can be shortened for the regeneration of smaller defects or by mixing with autologous/allogenic bone.



Histology of a biopsy harvested 24 weeks after lateral augmentation in dogs using maxresorb®.
maxresorb® particles are integrated into the newly formed bone and starting resorption of particles can be observed.
(courtesy of Prof. Dr. Dr. D. Rothamel, Germany)

What are the advantages of maxresorb® compared to bovine bone substitutes?

- maxresorb® is a 100% synthetic, thus very safe biomaterial (not even theoretical risk of disease transmission with regard to raw material).
- Its use is not restricted by dietary or religious conflicts.
- Valid synthetic alternative to xenografts with regards to indications and handling.
- Composition and structure of synthetic bone grafts can be designed to obtain optimal material characteristics:
    - The micro-/macrostructure of maxresorb® is rationally designed to provide the ideal properties of a bone substitute, naming high porosity, interconnected pores and very rough, hydrophilic surface
    - Owing to its synthetic, biphasic composition (see questions 3 and 4), maxresorb® is characterized by a controlled resorption and full remodeling potential. After about 2-3 years the material will be replaced by patients' own bone

Are there indications where maxresorb® can be preferred over bovine bone?

maxresorb® can be regarded as a synthetic alternative to animal-derived bone (cerabone®). Generally, both products can be used for the same indications. Accordingly, maxresorb® is a good alternative for patients with ethical or safety concerns against the use of animal-derived bone or bone from human donors.

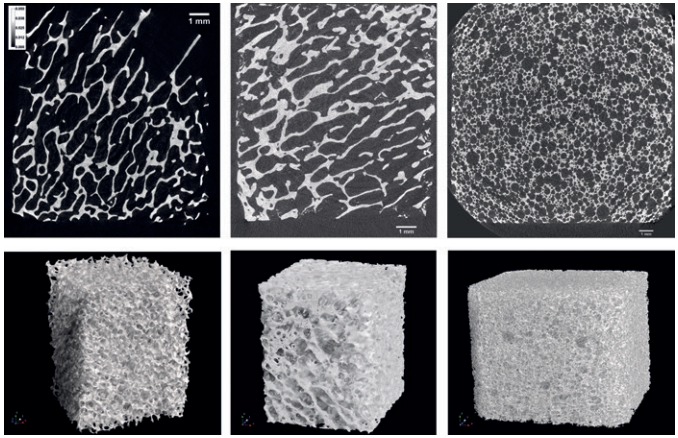
The optimal material for a certain indication depends on many other individual factors such as the patients' health status or the projected restoration. Opposite to cerabone®, maxresorb® will be remodeled and may therefore be preferred by some doctors or patients. This can also be an advantage when treating younger patients with good bone quality and regenerative potential. maxresorb® will remodel over time allowing complete regeneration of own bone with optimal biological structure.

How does the structure of maxresorb® look like?

Is there a difference in porosity between cerabone® and maxresorb®?

Both materials have a very high porosity and are characterized by a network of interconnected pores. **The average porosity of maxresorb® is even higher than that of cerabone® (~83% compared to ~72%).** The pore size of maxresorb® ranges from 100 to 1000 µm with an average pore size of 200 to 500 µm.

In addition, maxresorb® shows a very rough surface that promotes the adhesion of cells and signaling molecules and contributes to its osteoconductive properties and fast osseous integration.

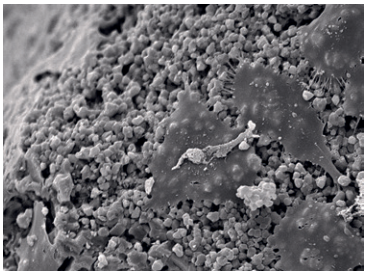


Micro CT images of cerabone®- (left), maxgraft®- (middle) and maxresorb®- (right) blocks showing the interconnected porosity of the materials.
(pictures from Trajkovski et al. 2018[4])

Is maxresorb® a hydrophilic material?

maxresorb® presents with an excellent hydrophilicity, which is due to its high interconnected porosity and very rough surface. The particles immediately take up blood and other liquids when getting into contact with them[3]. This improves the handling characteristics of the material, as the hydrated particles stick together, thus facilitating their application. In addition, blood uptake also improves the biological properties of the material. Growth factors and other signaling molecules from the blood easily bind to the inner and outer particle surface, supported by its nano structure.

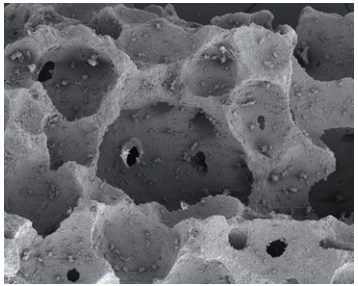
maxresorb® after rehydration in blood



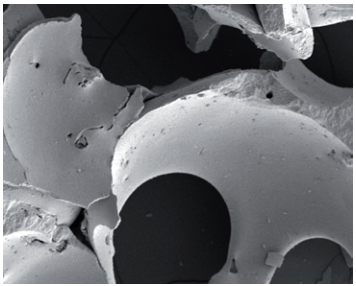
Osteoblast-like cells optimally grow on the rough surface of maxresorb®

Do all biphasic calcium phosphates show the same properties and structure?

No, because the material characteristics depend on the specific composition as well as the production process. The components (HA, β-TCP, α-TCP) as well as their ratio determine material properties such as osteoconduction. But also products with a similar composition (i.e. 60% HA and 40% β-TCP) can largely differ in their characteristics depending on the production process. For example maxresorb® provides a very porous structure and rough surface that is the basis for its excellent hydrophilicity, osteoconductive properties and bony integration. Other materials with the same composition have a much smoother surface and thus inferior hydrophilicity.



REM picture showing porosity and rough surface of maxresorb®



REM picture showing prorosity and surface of another biphasic CaP

How can I compare volume and weight of maxresorb®?

The bulk density of the small granules (0.5-1.0 mm) is approx. 0.52 g/cc

1cc maxresorb® S = 0.52 g

1g maxresorb® S = 1.9 cc

The bulk density of the large granules (0.8-1.5 mm) is approx. 0.35 g/cc

1cc maxresorb® L = 0.35 g

1g maxresorb® L = 2.85 cc

In which indications would you recommend the small maxresorb® particles, in which the large ones?

The small granules give better surface contouring, especially in the aesthetic region. This is also favorable when the granules are used to fill remaining gaps in case of a block grafting. Large particles are favorable, if large volumes (i.e. sinus lift) should be filled. In addition to the higher volume, there is more space between the large particles enabling a better revascularization of bigger defects.

How much volume of maxresorb® is lost over time compared to cerabone®?

Is it true that synthetic materials are less volume stable?

There are no studies directly comparing maxresorb® with cerabone®. However, studies on maxresorb® have shown that there is no volume loss of the augmented site 6-12 months post-surgery. Since maxresorb® is gradually remodeled, volume loss can occur, if no implants are placed within the first year after augmentation. In this case, the functional load is missing and the newly formed bone will start to resorb again. Consequently, a non-resorbing material like cerabone® is recommended, if it's not sure whether or when implants will be placed.

Generally, biphasic materials like maxresorb® offer the advantage of a controlled, and compared to pure β-TCP, much slower resorption. A study comparing maxresorb® with β-TCP in sinus lift procedure showed significantly more stable radiological bone volume for sites augmented with maxresorb® compared to sites treated with a pure β-TCP[5].
In addition, a study analyzed bone stability after lateral augmentation with maxresorb® and simultaneous implantation[6]. The radiological analysis revealed stable bone levels in all treated sites three years after loading.

Literature:

1. Manjubala et al. Bioactivity and osseointegration study of calcium phosphate ceramic of different chemical composition. J Biomed Mater Res. 2002;63(2):200-8.
2. Gauthier et al. Elaboration conditions influence physicochemical properties and in vivo bioactivity of macroporous biphasic calcium phosphate ceramics. Journal of materials science. Materials in medicine. 1999;10:199–204.
3. Schwartz et al. Biphasic synthetic bone substitute use in orthopaedic and trauma surgery: clinical, radiological and histological results. Journal of materials science. Materials in medicine. 1999;10:821–825.
4. Trajkovski et al. Hydrophilicity, Viscoelastic, and Physicochemical Properties Variations in Dental Bone Grafting Substitutes. Materials (Basel). 2018 Jan 30;11(2).
5. Jelusic et al. Monophasic β-TCP vs. biphasic HA/β-TCP in two-stage sinus floor augmentation procedures - a prospective randomized clinical trial. Clin Oral Implants Res. 2017 Oct;28(10):e175-e183.
6. Lorenz et al. Investigation of peri-implant tissue conditions and peri-implant tissue stability in implants placed with simultaneous augmentation procedure: a 3-year retrospective follow-up analysis of a newly developed bone level implant system. Int J Implant Dent. 2017 Sep 5;3(1):41.