Comparison of bone-graft substitutes

Risks and benefits of synthetic and bovine derivate materials

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The topic bone graft substitutes or bone regeneration and the question whether to apply xenografts, allografts or synthetically created materials still causes controversial discussions in oral and maxillofacial surgery. Yet, there are no doubts about the progress and the good clinical experiences made with biomimetic materials in the last two decades. The main discussion in this product group concerns a substitution with persisting volume and no or extremely slow resorption versus a complete degradation of the inserted material and transformation to vital bone with the unavoidable attendant symptom of controlled loss of volume. The following article shows risks and benefits of established bone-graft materials and why the author prefers synthetic bone regeneration.

Alloplasts and xenografts look the same both macroscopically and radiographically, and have almost identical handling characteristics. But here the similarities end. The measurement parameters for a successful grafting are the radiographic interpretation and the maintenance of volume of the regenerated ridge. More challenging is the interpretation of resorption rate, the percentage of vital bone and mineral density. Also important is the rate of complications and failures and if the material provides

Figs. 1 & 2: In the radiographs of the first case we can see two materials compared after seven years.
Figs. 3 & 4: Clinicaly the bone graft shows no vitalisation and no connection with the host bone.

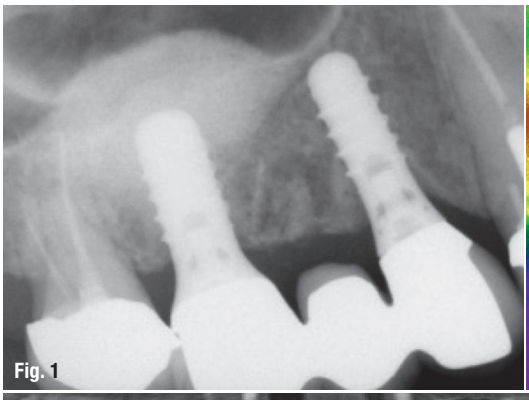


Fig. 1

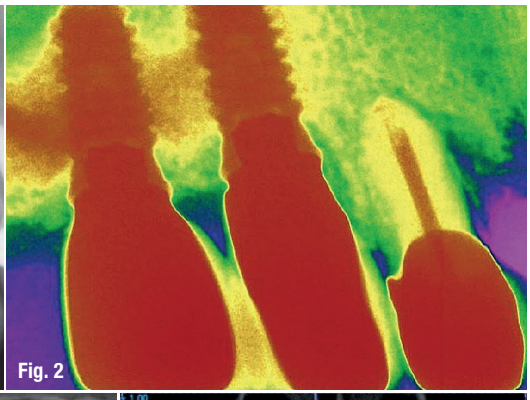


Fig. 2

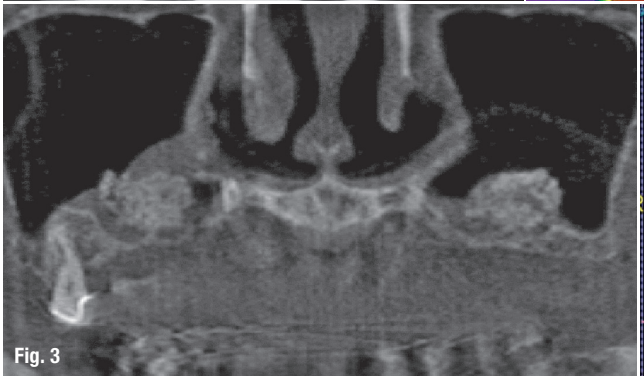


Fig. 3

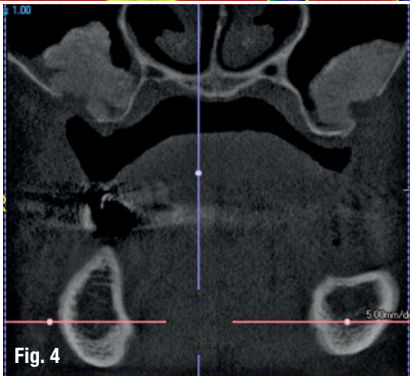
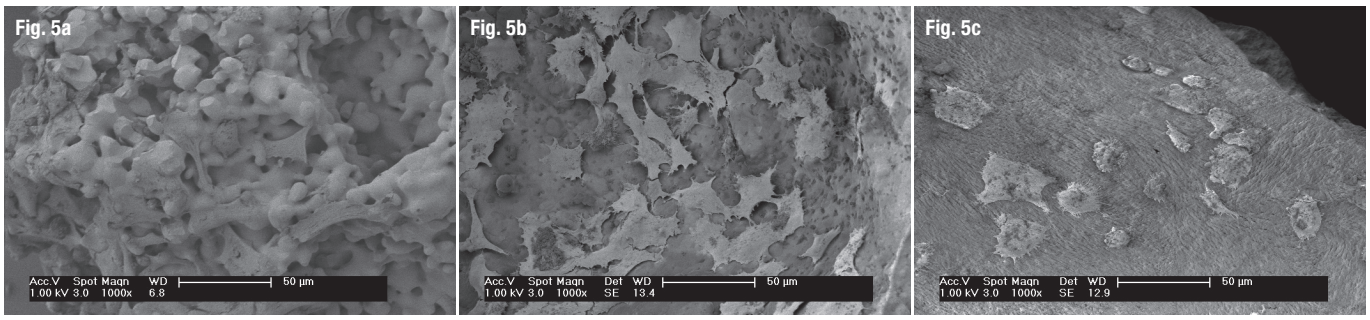


Fig. 4



Figs. 5a–c: Comparing test of different ceramic biomaterials for bone grafting with human osteoblasts (SAOS-2).

osteoinductive properties or if it is only osteoconductive.

Case examples

In the radiographs of the first case we can see two materials compared after seven years. Both materials provide volume for durable dental implants, but while the synthetic material is completely transformed to vital bone, the bovine material shows no signs of resorption or transformation (Figs. 1 & 2). Although the bovine material is not resorbed in this case, we find a stabile situation for the implants.

The second case shows the main complication associated with bovine bone substitute. The bone graft is rejected with a cover of inflamed connective tissue. Clinically, the bone graft shows neither vitalisation nor connection with the host bone (Figs. 3 & 4).

Highly resorbable alloplasts like pure β-tricalcium-phosphate do not show these reactions. Cerasorb®M, a more than 99 % pure β-tricalcium-phosphate with a polygonal, open cell structure and interconnecting pores allows a fast migration of osteoblasts and a complete transformation to endogenous, vital bone within six to nine months. As it has no biological history and the manufacturing process guarantees the highest-possible absence of microbes and pyrogens, the use of the material is regarded as uncritical.

In cell cultures the β-tricalcium-phosphate shows a significant advantage against bovine materials in colonisation with osteoblasts and an early biologisa-

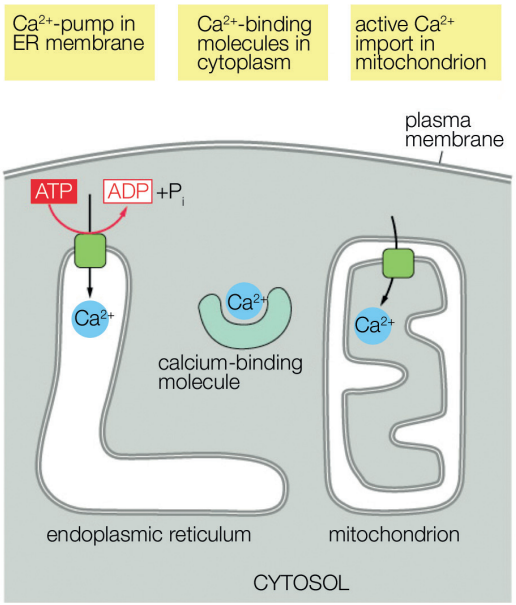


Fig. 6: Ca^{2+} function.

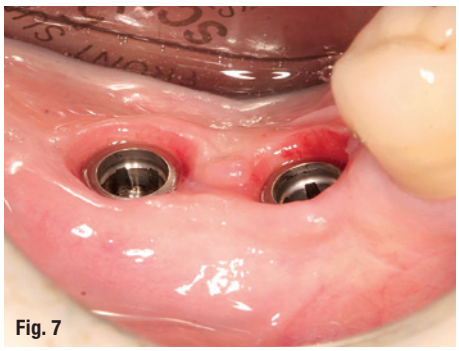


Fig. 7


Fig. 8

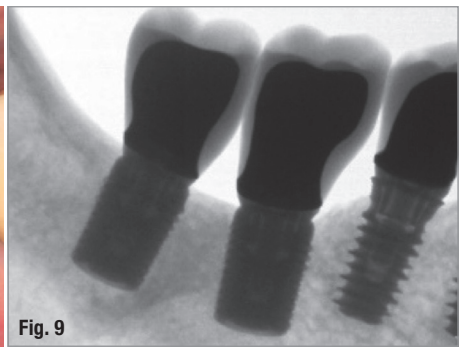


Fig. 9

Fig. 7: The image shows healthy soft tissue conditions and solid incorporated dental implants.
Figs. 8 & 9: After one year we can see an inflammation-free soft tissue and a complete bone regeneration in the augmented area.

tion, as it is shown by the studies of Bernhard A. et al. in 2010 (Figs. 5a–c).[1]

An important reason for the use of a highly resorbable alloplast is the biologic effect of the resorption of calcium phosphate materials (Fig. 6). During the resorptive phase, there is a contribution of the release of free ionic Ca^{2+}. Several studies[2-4] certify the importance of calcium for proliferation of osteoclasts and osteoinduction which is important for bone formation.[6] Further parameters for the evaluation of a bone regeneration material or a bone substitute are:

Primary particle size

To avoid cellular degradation, a primary particle size of 10 µm is required. It provides mechanical stability of the framework and also interconnecting microporosity. Grains lower than 10 µm stimulate phagocytosis from macrophages[8] and lead to an unintended anticipated loss of the bone graft material in the defect. As a result, a complete biological bone regeneration remains undone.

Stability of the framework

An early break-up in micro particles provokes the activity of phagocytosing macrophages and giant cells. This initiates an unspecific immunological reaction which deranges the regeneration and leads, in the worst case, to an excessively inflammatory reaction.

Open cell and spongious, interconnecting structure

These properties provide a continuous migration of blood vessels and osseointegration.

Biocompatibility

The biocompatibility of a bone-graft material is already demonstrated *in vitro* by an accelerated settlement with vital cells.[7] Materials with a structure similar to cancellous bone have an advantage in this regard.

Indications and examples

Filling and reconstruction of multi-wall bony defects, e.g. cysts, ridge- and socket preservation or sinus floor augmentation are typical indications for the use of Cerasorb®M.

Alveolar ridge augmentation with dental implants

The image shows healthy soft tissue conditions and solid incorporated dental (Fig. 7).

Final results

After one year we can see an inflammation-free soft tissue and a complete bone regeneration in the augmented area (Figs. 8 & 9).

Summary

Today we have different bone graft materials for preservation and reconstruction of the alveolar bone that allow a vast range of therapeutic approaches. After more than 20 years of experience with synthetic bone grafts and the excellent results achieved with Cerasorb®M no disadvantage can be seen in materials of biological origin. The obvious disadvantages of bovine materials are a low percentage of vital bone with a lower stress bearing modulus. They do not release free ionic calcium, are not resorbable and their only function is that of a filler. The main disadvantage is that they may experience foreign body-reaction and require an intensive patient information.

Cerasorb®M is highly resorbable and replaced by autogenous bone at a rapid rate. It releases free ionic calcium (osteoinductive) and leads to a high percentage of vital bone. Also it provides a higher stress bearing modulus from an increased density. Last but not least, there is no foreign-body reaction and now risk of transmitting prions—it is safe._

Literature

contact

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