Paving the way for a patient-friendly, minimally invasive approach in alveolar ridge augmentation

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Dental implantology is currently one of the most important treatment strategies for the replacement of missing teeth. The aim is to achieve a functionally stable, long-lasting, and esthetic outcome. Due to the reduced mechanical challenge, tooth loss induces progressive bone tissue atrophy. Thus, it is often necessary to reconstruct alveolar ridges before implants can be inserted.

Autografts

For three-dimensional augmentations in cases of extensively atrophic ridges, onlay block grafting is the method of choice. Autologous bone is still considered the gold standard in block grafting. However, the intra-oral availability of autologous bone for transplantation is limited. Therefore, bone harvesting from the iliac crest is required in cases of large defects.

Tissue harvesting, however, involves a second surgical site that is frequently associated with potential donor site morbidity and increased risk of pain. Furthermore, the of bone from the iliac crest is often associated with pronounced and long-term neurological symptoms.

Allografts

Alternatively, allogenic bone (human donor tissue, allograft) may be applied to avoid the additional risks that come with harvesting autologous bone. Due to its physiological structure, allogenic bone provides an ideal matrix for revascularization and new bone formation. Since it is fully resorbable, it supports natural bone remodeling. Moreover, allografts are biocompatible and, like autografts, do not induce immunological reactions[1].

Histological studies of the final stages of graft incorporation identified no difference between allografts and autografts[2,3]. The allogenic bone tissue originates from living donors who are undergoing total hip replacement surgery and are willing to donate their femoral heads to support the supply of bone graft material for medical use. Donors have to meet high standard criteria in terms of their health status in order to be selected; systemic and neurological diseases, acute or chronic infections, and existing or past malignancies are only a few of the exclusion criteria.

Every single donor undergoes serological testing to detect the presence of virus antigens by nucleic acid testing (NAT). The donated tissue is processed in a multi-level cleaning process, which removes organic components and non-collagenous proteins from the mineral phase of the bone. This process is also validated for its effectiveness to reliably inactivate potentially present viruses and bacteria. The unique processing of the donor tissue preserves the natural collagen content of the allograft bone, rendering a material with increased flexibility, simple handling, and more potential applications as compared to synthetic or bovine bone substitutes.

Classical onlay block grafting

The most important application for allografts is onlay block grafting; in the three-dimensional reconstruction of large defects, the block allograft ensures the necessary volume stability during graft incorporation. However, it is crucial during this initial phase of vascularization

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and graft incorporation to establish the largest possible contact area between the block and the local bone bed.

During conventional block grafting, a standardized square block has to be manually modified for adaptation to the surface of the local bone during the surgical procedure. It is a technique-sensitive and time-consuming process. Moreover, the prolonged exposure of the surgical site to saliva and air increases the risk of infection and delayed wound healing.

Customized allogenic bone transplants for onlay block grafting

botiss offers a new technology which provides the clinical user with a pre-fabricated, customized allogenic bone block, individually designed to match the patient's defect. The individual maxgraft® bonebuilder block (Figs. 1, 2) is designed using three-dimensional digital radiographs (CT/ CBCT) of the defect and CAD/CAM (computer-aided design/computer-aided manufacturing) technology. The radiological data is transferred into CAD/CAM planning software that builds a three-dimensional digital model of the scans (Figs. 3-6, patient data provided by Dr Markus Schlee, Forchheim, Germany). Based on this virtual model, the botiss specialists design the allograft block directly on the virtual defect with the use of a digital backward planning concept (Figs. 7-10, patient data provided by Masoud Memari, Budapest, Hungary). Starting with the design of a possible superconstruction, the approximate implant position may be mimicked and virtual implants inserted. If the implants are digitally planned by the clinical user, these

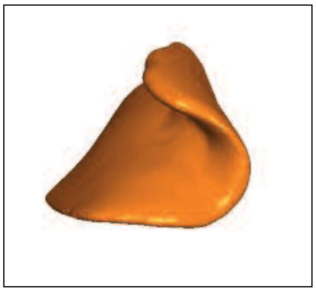
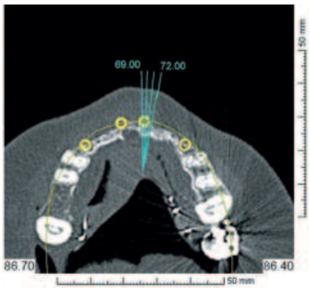


Figure 1

Figure 2



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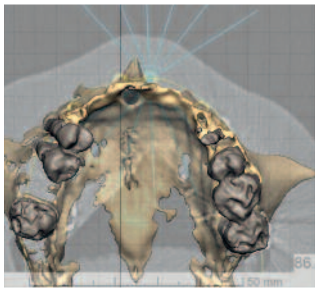

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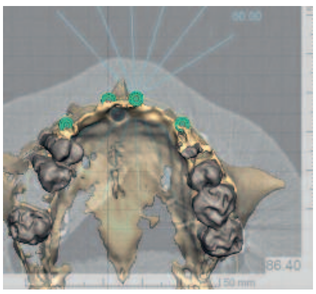

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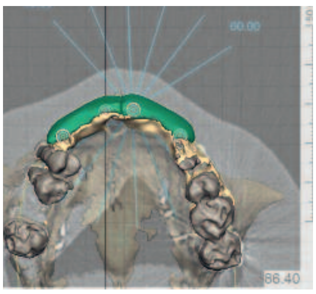

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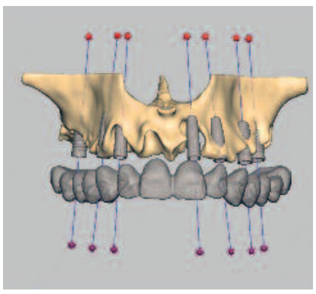

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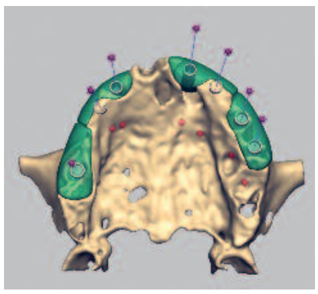

Figure 8

Figures 1, 2: maxgraft® bonebuilder – from the CAD/CAM-based 3D design to the customized allogenic bone implant.
Figures 3-6: Conversion of a CT/CBCT scan into a 3D model. Digitally planned implants can be transferred into the planning software and the customized bone block can be designed according to the alveolar ridge required in order to achieve stable implant positioning (patient data provided by Dr Markus Schlee, Forchheim, Germany).
Figures 7-10: Complex reconstruction of the maxillary ridge by digital backward planning – from superconstruction to customized bone blocks (patient data provided by Masoud Memari, Budapest, Hungary).

data can be transferred and the exact implant positions can be displayed in the 3D model. The block graft is subsequently designed to fit around the virtual implants, according to the final bone bed needed for stable implant insertion.

Individually designed in close cooperation between clinical user, CAD specialist, and tissue bank

The complete planning process is a product of direct interaction between the clinical user, the CAD specialist, and the producing tissue bank. Bone blocks are individually designed to meet the requirements for sufficient augmentation of the alveolar ridge in careful consideration of the soft tissue situation of the patient, which can only be assessed by the attending surgeon himself. The final 3D version of the bone block is converted into a *.stl file and transferred to the botiss partner tissue bank C+TBA (Cells and Tissuebank Austria, Krems). The block is produced under cleanroom conditions in accordance with pharmaceutical standards. The *.stl file is imported into a CNC-milling machine in which, after a simulated test run (Figs. 11, 12), the final graft is produced from a partially processed allogenic block. After packaging and final sterilization, the maxgraft® bonebuilder block is sent directly to the clinical user. In surgery, after it is brought into position, the maxgraft® bonebuilder block is fixed with regular osteosynthesis screws. Residual gaps can be filled with bone regeneration material and the augmentation site is covered with a collagen membrane before the wound is closed tension-free (Figs. 13-15).

Reduced surgery time, quick and uneventful wound healing

The pronounced fitting accuracy of the bone builder block facilitates optimal revascularization and graft incorporation. The operation time during block grafting is significantly reduced, thereby promoting quick and uneventful wound healing. It also allows the surgeon to focus on the management of the soft tissue, which is the actual key for success[4,5,6].

Due to the significant reduction in operating time, costs and, most importantly, patient morbidity, the unique maxgraft® bonebuilder technology paves the way for a patient-friendly, minimally invasive approach in alveolar ridge augmentation.

Scientific references of this article:
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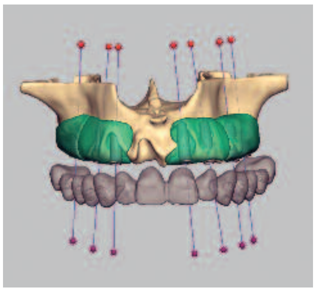

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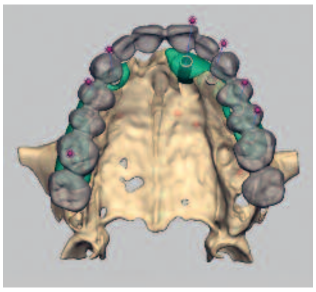

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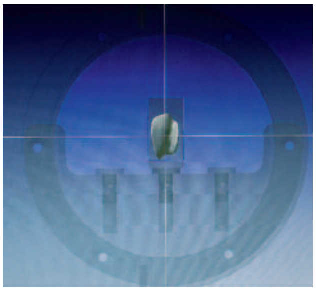

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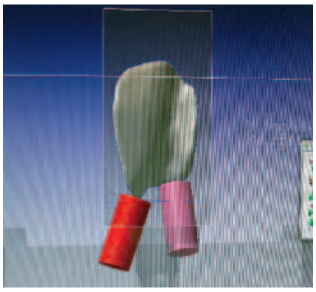

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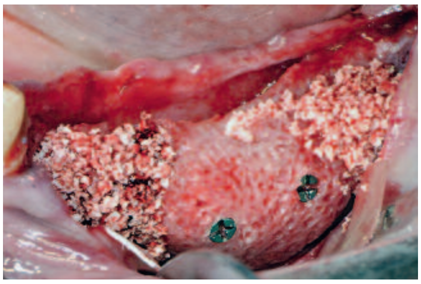

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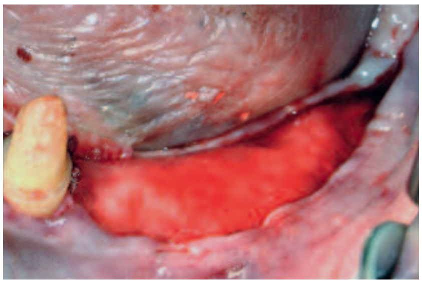

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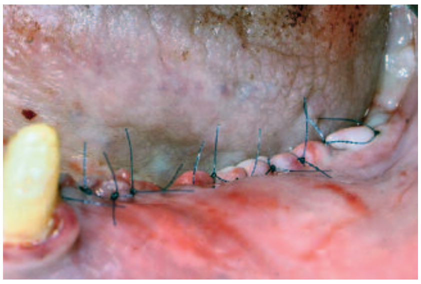

Figure 15

*Figures 11, 12: Digital simulation of the milling process after import of the *.stl file in the CNC-milling machine.*
Figures 13-15: Handling of maxgraft® bonebuilder in surgery. Fixation by osteosynthesis screws, filling of residual gaps with bone regeneration material (here: botiss cerabone®), covering of the augmentation site with a collagen membrane (here: botiss collprotect® membrane), and tension-free wound closure.