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Clinical Paper
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Guided bone regeneration using individualized ceramic sheets

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Abstract. Guided bone regeneration (GBR) describes the use of membranes to regenerate bony defects. A membrane for GBR needs to be biocompatible, cell-occlusive, non-toxic, and mouldable, and possess space-maintaining properties including stability. The purpose of this pilot study was to describe a new method of GBR using individualized ceramic sheets to perfect bone regeneration prior to implant placement; bone regeneration was assessed using traditional histology and three-dimensional (3D) volumetric changes in the bone and soft tissue. Three patients were included. After full-thickness flap reflection, the individualized ceramic sheets were fixed. The sites were left to heal for 7 months. All patients were evaluated preoperatively and at 7 months postoperative using cone beam computed tomography and 3D optical equipment. Samples of the regenerated bone and soft tissue were collected and analyzed. The bone regenerated in the entire interior volume of all sheets. Bone biopsies revealed newly formed trabecular bone with a lamellar structure. Soft tissue biopsies showed connective tissue with no signs of an inflammatory response. This was considered to be newly formed periosteum. Thus ceramic individualized sheets can be used to regenerate large volumes of bone in both vertical and horizontal directions independent of the bone defect and with good biological acceptance of the material.

Key words: ceramic; membrane; guided bone regeneration; vertical; human.

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When optimal anatomical conditions for implant installation do not exist, the situation must be changed, if possible. Several techniques to improve the height and width of the alveolar process, including block grafts and particulated grafts, distraction osteogenesis, bone splitting techniques, sinus floor elevation, and membranes, have been reported.[1–3] Unfortunately, the use of these methods may result in undesirable side effects such as infection, material exposure, and absence of healing linked to the material or surgical techniques.

Guided bone regeneration (GBR) describes the use of membranes to regenerate lost bone.[4] The basic requirements of membranes for GBR are biocompatibility, cell-occlusive properties, possibility of integrating, mouldability, and space-maintaining properties including stability. Regarding resorbable membranes, they should not produce any rest products, as these may have an adverse effect on the bone regeneration. Membranes described in both experimental and clinical studies have been the same for a long period of time, e.g. expanded polytetrafluoroethylene (ePTFE), collagen, and titanium mesh.[5] None of these materials presents material properties that fulfil the defined basic requirements for an optimal membrane material.

Titanium mesh membranes offer superb mechanical properties for GBR treatment in larger areas.[6] Unfortunately, exposure all too often presents clinically, which can lead to unaesthetic results and infection and thereby failure of the treatment.[7]

Inert high-strength ceramics such as zirconia form a group of materials that has not previously been used for the treatment of patients by GBR. This is a group of materials with properties that might solve the most obvious clinical dilemmas, like exposure of the materials and lack of stability in terms of larger GBR treatments.

When bone regeneration treatments prior to the installation of dental implants are evaluated, the terms 'implant success' and 'implant survival' are often used. The measurement of these values helps the clinician very little in the selection of an appropriate bone regenerating technique, as the evaluation is focused on the titanium implants rather than the bone volume or the aesthetic results achieved.[8] The use of superimposed cone beam computed tomography (CBCT) images[9] and of optical shape alterations in the soft tissue[10] are examples of techniques easily used to more adequately describe the potential of a bone regeneration technique, thereby not diverting focus onto the secondary treatment, the dental implant.

The purpose of this pilot study was to describe a new method using individualized ceramic sheets to regenerate bone, aimed at optimizing the anatomical situation in order to facilitate implant installation; furthermore it was aimed to present visual evaluation techniques besides traditional histology, using three-dimensional (3D) volumetric changes in both bone and soft tissue.

The successful outcome of this case series study has encouraged an extended series of investigations to further elucidate the potential of individualized ceramic sheets.

Materials and methods

Patients

The study was approved by the regional ethics committee. Three patients, two female and one male, were included in this pilot study. They were referred to the clinic for the installation of implants. All patients had inadequate bone volume for the optimal installation of implants and required bone regeneration prior to implant surgery. The patients were selected according to the specific site of bone regeneration: patient 1 had a posterior maxillary bone deficiency, patient 2 had an anterior maxillary bone deficiency, and patient 3 had a posterior mandibular bone deficiency. Thus, the patients represented areas known to be a challenge to the surgeon with regard to the bone regeneration technique prior to implant surgery. All patients were examined preoperatively, and one panoramic image and one CBCT scan of the area of interest were obtained.

Patient 1: posterior maxillary bone deficiency

Patient 1 was a 68-year-old woman referred to the clinic for implant installation in the upper right jaw. She was edentulous from tooth 12 and posteriorly due to earlier periodontal disease and wished to have permanent rehabilitation of this area. Her medical history was significant for hypothyroidism, hypotension, and depression. She was on treatment with levothyroxine, etilefrine, and nortriptyline. She was allergic to sulfa. She was a non-smoker.

In region 12–13, the alveolar crest was 2–3 mm in width and 7–8 mm in height. In region 14, the alveolar crest was 2 mm in width and 5 mm in height. In region 15–17, the width of the alveolar crest was 2 mm with a height of 0–1 mm. The clinical situation at insertion can be seen in Fig. 1.

Patient 2: anterior maxillary bone deficiency

Patient 2 was a 32-year-old man who had suffered a road traffic accident. He was brought to the emergency department with major pan-facial fractures, including a severe dentoalveolar crest fracture in the upper right side of the jaw, as well as exarticulation of his upper right central and lateral incisors which were never found. After primary treatment and healing of the facial fractures, it was decided to rehabilitate his occlusion by bone regeneration and dental implants. He was otherwise fit and well, without any regular medication or allergies. He was a non-smoker.

In region 11, the alveolar crest was 2–5 mm in width, varying within the interval, and the height was 14 mm to the floor of the nasal cavity. In region 12, the alveolar crest was 2–3 mm in width and the height was 8 mm to the floor of the nasal cavity. The clinical situation at insertion can be seen in Fig. 2.

Patient 3: posterior mandibular bone deficiency

Patient 3 was a 52-year-old woman referred for the installation of implants bilaterally in the lower jaw in regions 34–35 and 44–45. She was fit and well, had no allergies, was taking no medication, and was not smoking. On examination, she presented a greatly resorbed alveolar crest bilaterally. Her teeth in these areas had

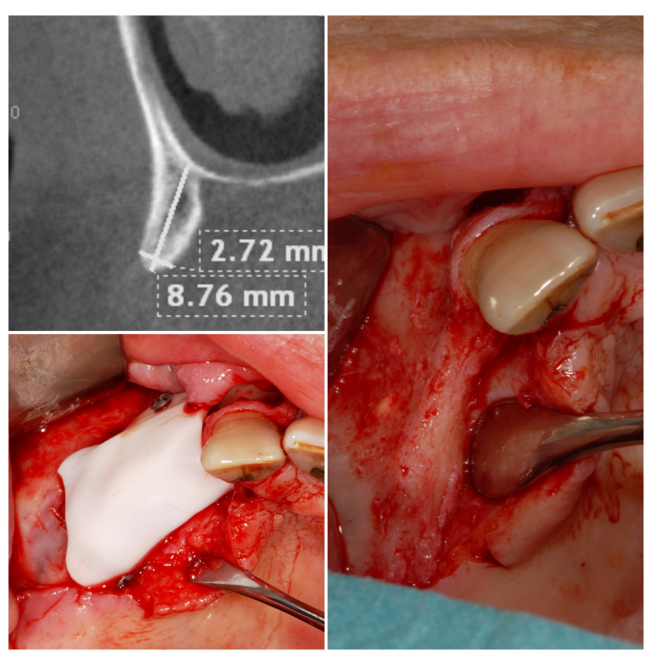

Fig. 1. Patient 1: images obtained preoperatively and during insertion of a ceramic sheet.