Guided bone regeneration in the pre-implantation phase

P. Poleník[1]

Implantologie Journal 5/2007

Bone regeneration is a complex procedure that plays an important role in many fields of medicine, including dentistry. It is mainly connected to certain defects of the bone, and is a component of the complex regeneration of periodontal tissues. Intraoral bone regeneration is important in planning of implant insertion.

For successful bone regeneration procedures need to follow various basic requirements. There are several factors that might, under certain conditions and in certain situations, have a negative impact on bone regeneration. For example, tissue regeneration within an area of periodontal disease is likely to be affected by bacterial infection. To promote bone regeneration in the area not in direct contact with the periodontal disease, the bone regeneration site can be isolated. On the other hand, this limits the source of cells that can contribute to the bone regeneration process only to those cells located in adjacent bone marrow, whereas in a periodontal site multipotential mesenchymal cells of periodontal ligaments are also available.

The regeneration procedure requires a suitable matrix to provide the skeleton for future bone tissue and a suitable environment for cells involved in the regeneration process. The structure resembling a labyrinth needs to be of the size of adhering cells and enable their interaction. The same material should prevent unwanted cells from entering the site. The optimal pore size should be between 200 – 400 μm, as this size reflects the average size of osteon in humans (which is ca. 230 μm). The surface topography of the material can also affect the proliferation activity of osteoblasts. Such a mechanism is especially important in resorbable materials in which the characteristics of the material undergoes continuous change.

Another vital characteristic of the matrix is its ability to induce vascularization of the regeneration site. The material should be resorbable to be able to subsequently give space to the newly growing bone. The material components themselves may also participate in creating the structure of the newly growing bone.

An important role in the bone regeneration process is also played by humoral factors - these perform an irreplaceable role in governing all ongoing reactions and are especially responsible for their coordination in time. The cascade process of bone regeneration is mainly run by transforming and growth factors. The transforming factors, in fact, are responsible for a recapitulation of the cell transformation events that occur during embryonic development, the growth factors being engaged in further cell production and differentiation. In connection with bone regeneration are the functions of the transforming growth factor–ß (TGF-ß), bone morphogenetic proteins (BMP), fibroblast growth factor (FGF), platelet-derived growth factor (PDGF), epidermal growth factor (EGF), insulin-like growth factor (IGF) and vascular endothelial growth factor (VEGF).

Transforming growth factors play an irreplaceable role in the proliferation and differentiation of osteoprogenitor cells and osteoblasts. The bone morphogenetic proteins induce the transformation of mesenchymal cells into cells forming bone tissue.

Platelets are a suitable source of growth factors – after degranulation they release a number of the growth factors named above. The procedure is not technically complicated and, given certain preconditions, can be performed in any dental surgery.

The presented study aimed at verifying the function of a matrix consisting of porous ß- tricalciumphosphate and platelet-derived growth factors in the reconstruction of alveolar ridge defects prior to implant placement into the bone.

Material and methods

Twelve patients (32-48 years) were treated for horizontal defects of the alveolar ridge caused either as a result of trauma or periodontal disease. In all patients implants were subsequently inserted into the bone. At the time of implant insertion, some bone material was obtained in order for an histological survey to be undertaken to evaluate the efficacy of the regenerative system used.

Bone defects were treated using porous ß-tricalciumphosphate (Poresorb - TCP, Lasak Ltd., Czech Republic). The structure of Poresorb - TCP is similar to the structure of spongiform bone with a macroporosity of ca. 100 μm and a microporosity of ca. 5 μm. Macroporosity is important for the settlement of regenerative cells, whilst microporosity is important for the adherence of protein mediators and for regenerating vascularization.

Prior to surgery, from each patient 20 ml of anticoagulated venous blood was taken; this was centrifuged in two steps to obtain platelet-rich plasma (PRP) that was further treated by adding calcium chloride and thrombin. In this way, platelet alpha-granules are degraded and growth factors released that are then ready to be used for the reparation and regeneration of integral tissue. The gel that is produced is a suitable carrier for the powdered Poresorb – TCP and when both are mixed together a material that is easily applied is obtained for use in bone defects.

A fully-mobilised mucoperiosteal flap was raised at the site of the defective alveolar ridge under local anaesthesia. The surface of the defected bone was then perforated to allow better contact between the augmentation site and bone marrow. The gel-like material with added Poresorb – TCP granules was used to repair the bone defect, i.e. to reconstruct the bone shape reaching a slightly larger volume. A collagen membrane was employed over the augmentation site to exclude unwanted cells from the defect area. Subsequently the mucoperiosteal flap was sutured back. The operated site was protected against mechanical damage and during the healing period an intensive antibacterial regime was ensured. Nine months later, an X-ray was taken and implants placed into the bone. Samples of the newly-formed alveolar bone were obtained for histological evaluation using a 2 mm drill. The bone samples were stained using hematoxylin-eosin and Goldner trichrome.

[1] Clinic of Dental Medicine, Medical Faculty, Charles University, Czech Republic

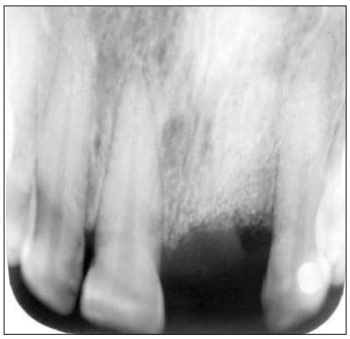

Fig. 1: X-ray taken in the area of tooth # 21 nine months after the guided bone regeneration treatment

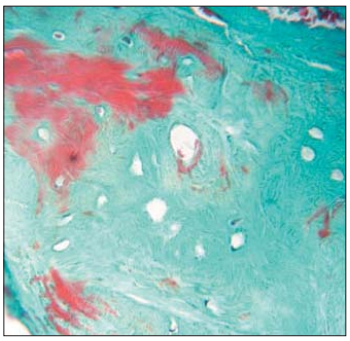

Fig. 2: Histological picture of a newly-formed bone collected from the regenerated area at the time of implant insertion. In trichrome staining, the developed lamellar bone is seen green. Visible are small remains of Poresorb - TCP granules.

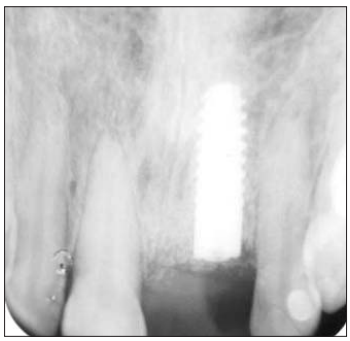

Fig. 3: X-ray showing the healed implant

Results

The healing of soft tissue following augmentation was without complications and the augmented site fully integrated. Radiographic evaluation nine moths later showed that the structure of the newly-formed bone was identical to standard bone and also the torque applied to the bone tissue during preparation for implant placement was equivalent (Fig. 1).
The histological assessment of bone specimen material showed, to a complete extent, the formation of lamellar bone with remains of Poresorb - TCP granules (Fig. 2). Also vascularization of the bone tissue was normal. Figure 3 shows radiograph of the operated site with a healed-in implant.

Summary

The presented results show that porous ß-tricalciumphosphate together with platelet-derived growth factors is able to ensure the regeneration of good-quality bone tissue. The use of platelet-rich plasma (PRP), and thus platelet-derived growth factors, has been described in many papers with varying results. Some papers present a positive impact of PDGF on tissue regeneration, others no effect at all. The most likely explanation for such variable findings is a differing procedure for the separation of PDGFs and also the characteristics of the materials used as a carrier for the cellular and humoral components. The most important characteristic is the ability of the material to adsorb proteins. In an ideal situation the adsorbed proteins should be subsequently gradually released; in this way the dynamics of the growth factors and their participation in individual reactions is regulated. Despite the fact that for therapeutic treatment the platelet-derived growth factors are supplied in quantities highly in excess of the physiological need, it is important to ensure that they are present for a sufficient time at a given site, as otherwise their effect might be negligible. Poresorb - TCP, the material that we have used in this study, is capable of ensuring proper PDGF functioning and thus contributes to new bone formation. In addition, Poresorb - TCP is a material that is resorbable and nine months following its application was almost undetectable in the histological evaluation. In combination with the membrane technique, unwanted cells did not interfere with the healing process. As the placed implants have been functional for several years now, the mechanical bone quality can also be considered to be satisfactory.