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Microarchitectural study of the augmented bone following ridge preservation with a porcine xenograft and a collagen membrane: preliminary report of a prospective clinical, histological, and micro-computed tomography analysis

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Abstract. Socket preservation using a combination of porcine xenograft and collagen membrane maintains the vertical and horizontal dimensions of the ridge. The aim of this study was to evaluate the microarchitecture of the grafted area by histological analysis and micro-computed tomography. Patients in the test group (group 1; nine patients) underwent socket preservation, while the sockets in the control group (group 2; eight patients) were allowed to heal without preservation. After a 6-month healing period, bone core biopsy samples were obtained and implants were placed in the augmented sites in the test group (12 biopsy samples) and the non-augmented

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sockets of the control group (12 biopsy samples). Analysis of the biopsy samples obtained from group 1 revealed that particles of the graft were surrounded by newly formed bone in eight cases and by granulation tissue in four cases. Micromorphometric data showed statistically significant differences in several parameters between the microarchitecture of the native bone and the newly formed bone within the augmented sites, which suggests that the xenograft particles interfere with the bony healing of the alveoli.

Key words: alveolar ridge preservation; bone graft material; xenograft; porcine bone; X-ray microtomography; histology.

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The alveolar ridge is a tooth-dependent structure of the jaw. Its development is induced by tooth eruption, and the loss of teeth results in resorption and atrophy of the alveolar ridge.[1–6] During the first year after tooth removal, there is a 25% decrease in the volume of the ridge, and its width reduces by 40–60% in the first 3 years.[4,5,7–9] Severe atrophy of the ridge prevents favourable prosthetic positioning of endosseous implants; therefore, ridge augmentation may be necessary for implant placement.[1–5]

Preservation of the alveolus following tooth extraction predictably maintains the bone volume.[1–6,10,11] Several techniques and biomaterials for alveolus preservation have been described in the literature.[3–5,10–13] Studies have shown that the use of bone substitute materials with or without bioresorbable or non-resorbable barrier membranes significantly reduces the horizontal and vertical bone loss following extraction.[1–3,5,6,10,11] There are reports of the successful application of several bone graft materials in ridge preservation, i.e. autologous bone, mineralized freeze-dried bone allograft (FDBA), demineralized freeze-dried bone allograft (DFDBA), alloplastic polymers, nanocrystalline hydroxyapatite bioactive glass, biphasic ceramic bone substitute, porous bovine bone mineral (PBBM), and other xenografts of bovine and porcine origin.[1–6,10,11,14–21] However, all of these materials interfere with normal extraction socket healing.[10,15,22–24] Autologous bone is the gold standard bone substitute material; however, morbidity related to the donor region is a disadvantage of the use of autologous bone.[3,4,15]

A xenograft of porcine origin has recently been studied. It is a particulated, high-porosity, corticocancellous xenograft.[1,2,6,11,25] The porcine bone undergoes thermal processing (maximum temperature 130 °C) to completely eliminate any pathogenic elements and to maintain the structure and composition of the natural collagen and hydroxyapatite.[25] Type I collagen induces the osteoblastic differentiation of bone marrow cells.[26] The processing of this biomaterial results in greater degradation of the granules compared to other xenografts.[27]

Micro-computed tomography (micro-CT) has been used to analyze the internal structure of hard tissues in high resolution. Compared to histological sectioning, it is a quick, reproducible method that is also non-destructive, thus allowing further processing of the specimen. According to the literature, micro-CT analysis is a viable method to study the integration of bone augmentation materials.[28–38]

The aim of this prospective study was to clinically examine and then investigate the integration of porcine xenografts used in ridge preservation by histological and micro-CT analysis. The aim was to determine whether socket grafting interferes with natural bone healing.

Materials and methods

Patients

Patients who were periodontally healthy, older than 18 years of age, able to sign an informed consent form, and who needed implant-supported restoration were included in this study. The exclusion criteria were as follows: history of systemic diseases that would contraindicate oral surgical treatment, unwillingness to return for follow-up examinations, smoking, and pregnancy. The procedures used in the study were explained thoroughly to the patients, and they signed informed consent forms. The study was approved by the Regional and Institutional Committee of Science and Research Ethics and the Hungarian Office of Health Authorisation and Administrative Procedures, and was conducted in accordance with the Declaration of Helsinki.

The patients were categorized into two study groups. The test group (group 1) consisted of nine patients who required ridge preservation to maintain sufficient bone volume for implant placement. These patients showed loss of buccal bone after tooth removal. Therefore, their sockets showed a three-wall bone morphology. The control group (group 2) consisted of eight patients who did not require ridge preservation in order to maintain the bone volume for implant placement. These patients showed an intact and thick buccal bone after tooth removal, and their alveoli presented a four-wall bone morphology.

Surgical treatment

All patients rinsed with 0.2% chlorhexidine solution for 1 min before surgery. The removal of teeth was performed in an atraumatic manner under local anaesthesia. The sockets were thoroughly debrided to remove all of the soft tissues.

Socket morphology was examined at this stage. If the buccal bone of the alveolus was missing and the socket presented a three-wall bone morphology, the socket was assigned to group 1 (test group). If an intact buccal bone wall was observed and the socket presented a four-wall bone morphology after tooth removal, the socket was assigned to group 2 (control group).

In group 1, an intrasulcular incision with or without crestal incision and two relieving incisions were made to raise a full-thickness flap. The corticocancellous porcine bone graft (Gen-Os; OsteoBiol, Tecnoss Dental, Torino, Italy) was packed into the socket and a porcine collagen membrane (Evolution; OsteoBiol, Tecnoss Dental) was used as the occlusive barrier. The buccal flap was mobilized to allow tension-free primary closure. The margins were stabilized with single interrupted sutures. The images presented in Fig. 1 show a preoperative radiograph and a cone beam CT image obtained after a 6-month healing period in one of the cases in group 1.

In group 2, sockets were left to heal without the use of socket preservation techniques.

Antibiotics (1 g amoxicillin–clavulanate twice a day for 5 days, or in the case of side effects or a known allergy to penicillin, 300 mg clindamycin four times a day for 4 days), anti-inflammatory drugs (50 mg diclofenac three times a day for 3 days), and chlorhexidine mouthwash