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Case Report

Horizontal Ridge Augmentation in Esthetic Zone Using Albumin Coated Bone Allograft

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Abstract

Investigating horizontal ridge augmentation in anterior maxilla using albumin coated allograft. Regenerative bone fills the defected ridge which has the same structure as the surrounding bone. The albumin coated bone allograft used in the present case allowed for successful horizontal ridge augmentation of a partially atrophic ridge. Both its effectiveness and its remodeling properties should be subjected to further investigations.

Keywords: *Horizontal Ridge Augmentation; Esthetic Zone; Albumin Coated Bone Allograft*

Introduction

The anterior maxilla is the most challenging zone regarding esthetics in implant dentistry. Many, if not most, cases in the anterior maxilla require horizontal ridge augmentation due to partial or complete loss of the labial bone plate following tooth extraction. Ridge deficiency in the anterior maxilla prevents primary implant stability or results in an inadequate implant position with compromised esthetics and function. Therefore, horizontal ridge augmentation is an important issue before or during implant placement [1].

Alveolar ridge rehabilitation can be undertaken at different time points during treatment, and is generally classified as simultaneous or staged. In the staged approach, the alveolar bone is first reconstructed in an initial surgery, and implant placement is then carried out 2 to 6 months later [2]. In contrast, in the simultaneous approach, implant placement and alveolar ridge reestablishment are undertaken in the same surgery. The simultaneous approach is obviously the preferred technique by the patient and clinician too, since it reduces treatment time and cost [3]. However, if the residual bone volume precludes primary implant stability, or results in inadequate prosthodontic implant positioning, the staged approach is recommended.

In the anterior maxilla (esthetic zone), a third component must be considered in the treatment decision process: the esthetic expectations of the patient and his/her esthetic profile (level of smile line, gingival biotype, soft tissue deficit, size of edentulous gap, and bone level at adjacent teeth).Treatment planning and precise scheduling of tooth extraction and implant placement are important issues to reduce healing periods, morbidity of the patient, and to create the fewest number of surgical interventions [1].

The risk of inadvertent bone loss is particularly high in the anterior maxilla which is commonly known to exhibit a thin (or even partially absent) labial bone plate. Since this bone plate mainly consists of the so called bundle bone, associated with the presence of a non-ankylotic tooth together with a viable periodontal ligament, removal of the root or post-traumatic root ankylosis will disturb this

functional unit, resulting in considerable resorption of the labial bone plate. As a consequence, many cases referred for implant treatment in the anterior maxilla present with horizontal bone deficiencies that requires horizontal bone augmentation [4].

Several surgical techniques have been described in the last four decades regarding reconstruction of deficient alveolar bone for supporting dental implants, e.g. particulate graft augmentation, block graft augmentation, ridge splitting or ridge expansion and distraction osteogenesis. Materials used for the reconstruction of alveolar bone include autogenous bone, allogeneic bone, xenografts, alloplasts, bone promoting proteins, barrier membranes, titanium meshes and foils, fixation screws, pins and plates, and bone transportation devices [5].

Allogeneic bone graft is usually the 2nd choice for clinical bone replacement [6]. Fresh, frozen, and freeze-dried allografts are seemed to be the most popular; however, there is not a well-established protocol for their manufacture [7,8]. For the patient safety the allografts are supposed to be subjected to disinfection so as to avoid the transfer of contagious agents from the donor to the recipient [9,10]. Freeze-drying technique allows the profound disinfection of allogeneic bone grafts with chemicals, like acids and ethylene-oxide because these agents are eliminating from the allograft during the freeze-drying. As the disadvantageous effect of such a disinfection the osteogenic cells are killed on the allograft and most of the osteoinductive proteins become denatured, which impairs the biological value of the allograft [10,11]. Thus, the lege artis manufactured freeze-dried allograft can be characterized by a good osteoconductivity but a low osteoinductive and osteogenic capability that ultimately result in its unreliable incorporation.

Replacement of the protein structure may improve the cell adhesion properties of freeze-dried allograft. Several proteins are used in cell culture for increasing attachment, among them bone structure proteins such as fibronectin and collagen I. It is common practice to soak plastic dishes in fibronectin solution which then significantly increases the seeding efficiency of added cells [12]. Although albumin acts as an anti-attachment protein in plastic surfaces, it is also the main component of culture media which is required for proliferation [13,14]. In order to improve the biological value of freeze-dried allograft, an optimized protein structure should be provided which allows the fast attachment and proliferation of bone forming cells after implantation of the graft.

Serum albumin is the most common protein in plasma, being responsible for numerous functions, like free radical scavenging, neutrophil adhesion and molecule transportation [15]. In addition, serum fractions like bovine serum albumin (BSA), or human serum albumin (HAS) are widely used additives in cell culture media, providing growth factors, carrying lipids, metals, and low molecular weight nutrients.8 Serum albumin was also shown to reduce the colonization of Staphylococcus aureus, Staphylococcus epidermidis, and Pseudomonas aeruginosa when applied as a coating on titanium surfaces [16,17]. Serum albumin coating also reduced infectious events in a rabbit model [18] therefore it could possibly function as a prophylactic agent against infectious complications in a variety of bone surgeries.

BSA was shown to improve adherence of osteoblast-like cells compared to adsorbed bone sialoprotein and osteopontin on hydroxyapatite surfaces [19]. The authors concluded that surface adsorbed albumin is changing the proliferation and attachment activity of the cells. Additionally, we found similar results on the surface of HSA treated surgical sutures [20].

Moreover, the albumin molecule has a relatively long half-life in serum, which is due to the salvaging mechanisms of albumin-binding cellular receptors [21,22]. The neonatal Fc receptor (FcRn), for example, protects the albumin molecule from intracellular degradation, which provides equivalent amounts of albumin as the liver produces [23], while the cubulin-megalin complex supports reabsorption from the glomerular filtrate [22]. Other surface glycoproteins, like gp18, 30 and 60 also have albumin binding affinity and play an important role in the homeostasis of the molecule [21,22]. Even though these albumin binding receptors exist, no certain pathway was identified proving the albumin molecule to be an extracellular messenger.

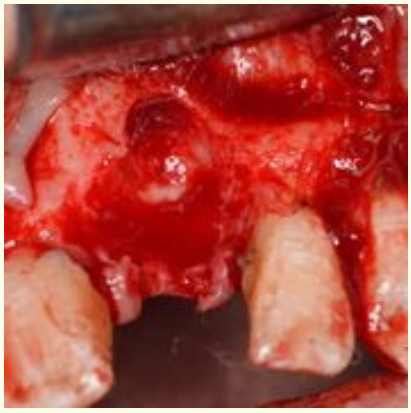
Even so, albumin seems to act as a self-supporting molecule after bone injury, since it is produced by osteoblasts at the trauma site and increases cell proliferation locally. According to the *in vitro* findings showing increased stem cell adherence onto albumin coated surfaces, it is also possible that the therapeutically increased local concentration of albumin recruits endogenous osteoblasts and supports their

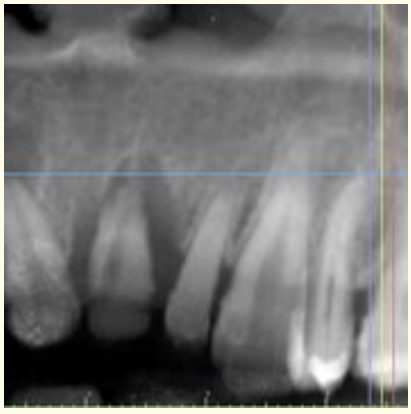
proliferation. After the albumin concentration decreases, osteoblasts differentiate resulting in faster ossification. This mode of action supports the *in vivo* experiments where serum albumin coated allografts and DBM were shown to successfully treat various bone defects [24,25]. Thus, albumin possibly supports bone tissue regeneration as an active molecule in addition to its bacteriostatic behavior and cell attachment properties [26].

The aim of the present study was to investigate horizontal ridge augmentation in esthetic zone using Albumin coated bone allograft clinically and radiographically.

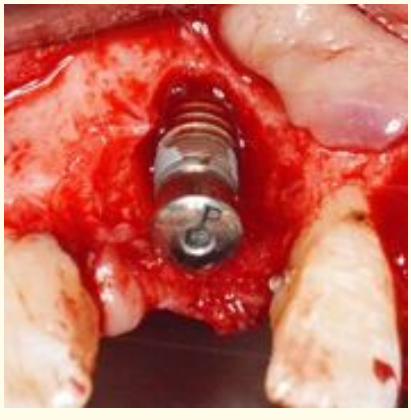
Case Description

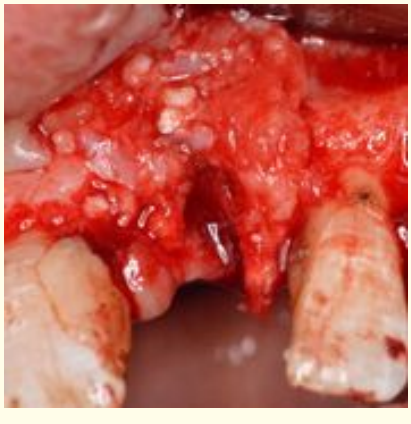
A 33 years old female patient presented with periodontally affected maxillary central incisor (left central). She required an implant supported fixed restoration. Upon clinical and radiological examination (Figure 1,2), we found that there was a significant labial bone loses "dehiscenced labial bone". A decision was taken to extract the hopeless tooth, immediate implant placement and ridge augmentation using Albumin coated bone allograft manufactured by OrthoSera@ (Figure 3) and titanium mesh was planned.

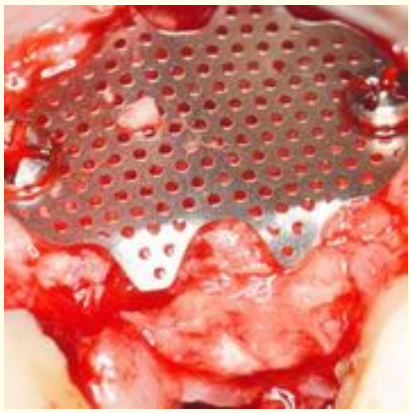




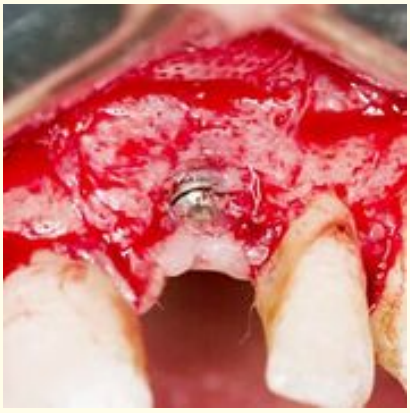
A prophylactic oral antibiotic, Augmantin@ 625 mg tid was used routinely, beginning 1 day prior to the procedure and continuing for 6 days postoperatively. Conventional pedicle flap was elevated after tooth extraction and immediate implant placement was carried out (Figure 4). Horizontal bone augmentation using albumin coated allograft and titanium mesh which was fixed by screws was done and then suturing (Figure 5, 6). Sutures were removed after two weeks.







After three months post-surgical, the patient came seeking for prosthetic part loading. Upon clinical and radiographic examination, there was enough bone height and thickness and good labial contour around the implant, so loading is feasible now. Another pedicel flap was carried out to remove the titanium mesh and then the prosthetic steps were performed (Figure 7).



Discussion

Bone deficiency in the anterior maxilla prevents primary implant stability or results in an inadequate implant position with compromised esthetics or function. Therefore, horizontal ridge augmentation is a prerequisite before or during implant placement [1].

Augmentation of insufficient bone volume can be brought about by different methods, including, particulate and block grafting materials, Guided Bone Regeneration with or without growth and differentiation factors, ridge splitting, expansion and distraction osteogenesis, either alone or in combination. These techniques may be used for horizontal/vertical ridge augmentation, socket preservation and sinus augmentation [2].

Autogenous bone harvested from either extraoral or intraoral sites is regarded as the "gold standard", and it remains the material of choice for cortical-cancellous blocks. However, its use has many drawbacks as risks of donor site morbidity: infections, immediate post-

operative pain and edema, neurosensory deficits, and hematomas. A variety of alternative allogeneic, alloplastic and xenogeneic bone grafting materials have been proposed in recent years, based on different biological mechanisms and bone regeneration principles, such as tissue engineering, and the osteoinductive and osteoconductive potential of different scaffolds [5].

Albumin coated bone allograft manufactured by OrthoSera@ was used in our study. Serum albumin is a well-known proliferation factor for stem cells in culture and we hypothesized that this feature may also be beneficial as a bone graft additive [27]. In previous *in vitro* experiments it was showed that freeze-dried serum albumin coating on human allografts provides a convenient milieu for mesenchymal stem cell (MSC) proliferation [24]. Albumin coated human allografts were also implanted in a rat nonunion femur model *in vivo*, where it was found significant defect consolidation at four weeks after implantation [28]. At this time point, albumin coated allografts successfully bridged nonunion bone defects, while uncoated grafts failed. Later, the safety and surgical applicability of albumin-coated allografts in a human experiment was investigated, during which albumin coated allografts were implanted in 10 cases of aseptic revision arthroplasty as a support for the metal prosthesis [5]. These experiments successfully showed the applicability of albumin coating and raised hope for better clinical outcome.

In another experiment, the serum albumin coated sutures were able to attach significantly more MSCs after 48 h compared with classical attachment proteins like fibronectin and poly- L-lysine. More recently, data showed increased early adhesion and faster spreading of human gingival fibroblasts on BSA coated titanium surfaces [29].

Serum albumin could have other favorable properties besides the above mentioned functions, like molecule transportation. In fact, Liu concluded that adsorbed BSA increased surface energy, roughness and the hydrophilicity of the coated surface, which features promoted the adherence of biological macromolecules and therefore increased the possible connecting points between cells and the material [29].

Numerous scientific publications are available showing that the increased number of local stem cell or precursor concentration combined with different scaffolds are potent alternatives of autologous bone replacement therapies [30,31]. The beneficial effects of increased number of local precursors are twofold. First, various stem cells are capable to differentiate into osteoblast. Second, stem cells have beneficial immunomodulatory and paracrine effects after injury as well.

Conclusion

Within the limitations of the case report, horizontal ridge augmentation at the anterior maxillary zone becomes a mandatory by increasing the esthetic demands. Using suitable type for grafting, specially the one with uploaded growth factors such as serum albumin coated demineralized bone allograft can provide better results. Serum albumin acts as a pro-attachment protein for mammalian cells, especially stem cells, while at the same time blocking bacterial colonization, making it a very favorable coating material for tissue engineering implants. Moreover, albumin acts as a carrier molecule for cytokines and growth factors. In addition, serum albumin shows direct beneficial regenerative effects in tissue engineering applications, promisingly in bone healing. These novel treatment strategies will benefit greatly from investigating albumin and redefining its place in the field of tissue engineering and regenerative medicine.

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