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Alveolar ridge preservation following tooth extraction – basic concepts

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ABSTRACT

After tooth extraction due different clinical situations, there are some physiological changes that include volumetric resorption of the bone, leading to changes in the dimensions and contours of the alveolar ridge that can negatively impact the aesthetic outcome of an implant or of a conventional prosthetic rehabilitation. In order to prevent and minimize adverse consequences from such dimensional changes, the present review aims to present some fundamental basis regarding alveolar ridge preservation and biomaterials used to prevent bone resorption.

Keywords: tooth extraction, healing, alveolar preservation, biomaterials

INTRODUCTION

The periodontium is an important structure that supports the maxillary tooth and is impacted by all dental changes, such as eruption and extraction [1]. The alveolar process is a tissue that is influenced by the presence or absence of teeth, tooth morphology, the direction in which the tooth will erupt [1], and the volume of the alveolar process [2].

Dental extractions are procedures performed daily by dentists and regarding to the main indication is represented by the dental caries [3,4]. Also, where reported other indications for tooth extractions, such as periodontitis, endodontic problems, orthodontic considerations, failure of eruption, part of a prosthetic treatment plan, [5,6] dental trauma, aesthetic, and other medical reasons that would justify this treatment.

After tooth extraction, there are physiological changes affecting the alveolar bone that surrounds the extraction socket [7]. These changes include bone formation in the socket as well as volumetric resorption leading to changes in the dimensions and contours of the alveolar ridge. Some studies reported that average reductions of 3.87 mm in the bucco-lingual ridge thickness and a vertical mid-buccal resorption of 1.67 mm are to be expected following unassisted socket healing [8]. Post extractional alveolar bone resorption varies among individuals and sites and involves both anterior and posterior teeth [9].

The resorption of the alveolar process frequently complicate implant placement and impair the aesthetic outcome of implant or conventional prosthetic rehabilitation. Thus, ridge preservation treatment protocols have been advocated to minimize the inevitable alveolar bone resorption and to ensure the support of an adequate ridge profile [10].

Different techniques and biomaterials have been investigated and a wide variety of alveolar ridge preservation treatment modalities have been described in the last twenty years. There are already in the literature several systematics reviews [11-13 that were designed to give the clinicians the state of

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art of these techniques to allow them to make the best clinical decision. However, there is limited information based on randomized clinical trials or clinical trials to address the real advantages of alveolar ridge preservation techniques. Unfortunately, is not clear yet, which technique and materials are the most suitable for socket preservation. Furthermore, is still unclear the need of a bone graft, a membrane or only soft tissue graft, as well as the influence of soft tissue impact to socket preservation [14].

The present review, aims to provide some basic concepts about alveolar ridge preservation and briefly present some characteristics of different biomaterials used to prevent bone resorption.

ALVEOLAR RIDGE HEALING AND REMODELING AFTER TOOTH EXTRACTION

Maxillary and mandibular bony complexes are composed by several anatomical structures with a proper function, composition, and physiology:

- The *basal bone* that develops together with the overall skeleton, and forms the body of mandible and maxilla;
- The *alveolar process* that develops following tooth eruption and contains the tooth alveolus;
- The *bundle bone* that lines the alveolar socket, extends coronally forming the crest of the buccal bone, and makes part of the periodontal structure as it encloses the external terminations of periodontal fibers (Sharpey's fibers) [15].

The magnitude and dynamics of the alveolar ridge's dimensional changes subsequent to tooth extraction are dictated and influenced by a variety of:

- Systemic factors like smoking, patient compliance
- Local factors like the extent of the traumatic injury during extraction, socket morphology, the presence of infection, the tooth type and position, the presence of periodontitis, the hard and soft tissue phenotype and the number and thickness of the remaining intact socket walls [16].

The alveolar ridge undergoes evident reduction in both vertical and horizontal directions [18-20]. The processes taking place after tooth removal were systematically reviewed in an article that included 20 human studies and aimed to assess the magnitude of dimensional changes of both the hard and soft tissues of the alveolar ridge after tooth extraction [1]. In summary, following single-tooth extraction, up to 50% of the ridge width will be resorbed and bone resorption will predominantly occur at the buccal aspect [21].

In the literature, are reported three healing timepoints for alveolar ridge preservation; these focus on the need for:

- Optimization of the soft tissues (soft-tissue preservation with 6–8 weeks of healing after tooth extraction);
- Optimization of the hard and soft tissues (hard- and soft-tissue preservation with 4–6 months of healing after tooth extraction); and

Optimization of hard tissues (hard-tissue preservation with > 6 months of healing after tooth extraction) [20].

Several studies have described the healing process after extractions both in animals and humans, providing a better understanding of post-extraction soft and hard tissue remodeling from a histologic perspective [9,21,22]. While bone remodeling is relatively well understood, a more thorough understanding of post-extraction soft tissue changes is required [23]. Thicker soft tissues have been shown to respond favorably after periodontal or implant surgery in terms of wound healing [24,25].

A systematic review analyzing dimensional changes of the alveolar ridge reported horizontal bone loss ranging from 29% to 63% and vertical bone loss ranging from 11% to 22% at 6 months after tooth extraction [1]. The resorption pattern is characterized by rapid reduction in the first 3–6 months, followed by gradual reduction thereafter [26]. Further, horizontal buccal bone resorption has been shown to reach as much as 56%, while lingual bone resorption has been reported to be up to 30% [27]. Major bone resorption of the vestibular wall of the extraction socket is related to a higher proportion of bundle bone, a tooth-dependent tissue through which the periodontal ligament fibers are anchored to the jaws, which undergoes resorption due to the loss of its function [28].

During post-extraction healing, soft tissue thickens while the bone is gradually resorbed [29]. Although one possible benefit of this process is that soft tissue thickness tends to increase, post-extraction soft tissue changes may potentially mask the true extent of alveolar ridge atrophy [13,29]. Therefore, alveolar ridge preservation does not prevent the ridge atrophy from occurring, but it may limit the extent to which it occurs [30].

BIOMATERIALS USED IN ALVEOLAR RIDGE PRESERVATION

Bone grafting materials are categorized into:

- autogenous,
- allografts,
- xenografts,
- and alloplasts.

All these materials has shown its efficacy in reducing dimensional shrinkage after tooth extraction [31,32]. Studies provide evidence that some graft materials, such as xenografts and alloplasts, may re-

sorb at a slower rate, with their remnant particles existing 7 months or more after the grafting procedure; thus, they may be more suitable for long-term alveolar ridge preservation [32-34]. On the other hand, allograft tends to resorb more quickly with fewer residual particles and induces more newly formed bone after 3 months of healing [33]. These properties may be more favorable for short-term alveolar ridge preservation. The long-term effect of residual grafting material on implant survival and success has not been reported [35].

Bone grafts generally refer to **autogenous** bone grafts and allogenous grafts. Autogenous grafts are harvested from the patient's body and are the "gold standard" material. Common donor sites include maxillary tuberosity, edentulous ridges, mandibular ramus, and mandibular symphysis intra-orally or the iliac crest, tibia extra-orally. Autogenous bone grafts are osteoconductive and osteoinductive and can induce osteogenesis. They are also biocompatible and nonimmunogenic. They can be of three main types: corticocancellous, cancellous, and cortical [36].

Allogenous grafts or allografts refer to grafts obtained from different individuals of the same species. Depending on their processing technique, they can be demineralized freeze-dried, freeze-dried, or fresh frozen. Demineralized bone allograft has osteoinductive properties as the demineralization process exposes bone morphogenetic protein. However, there are some disadvantages such as in increased risk of disease transmission and risks of immunogenic reaction with allografts [37,38].

Bone substitutes include **xenogenic grafts** that are obtained from different species and then them transplanted into humans. They are bovine, porcine, equine, or coralline in origin. Xenografts carry a higher risk of disease transmission and immunogenicity. Alloplasts are synthetic bone substitutes and primarily function as defect fillers. They include natural and synthetic polymers and bioceramics like hydroxyapatite. Since they are manufactured under controlled conditions, their properties like degradation rate and pore size can be controlled [38-40].

Xenografts such as Giestlich Bio-Oss® are integrated into bone, but are not absorbable, which allows the bone mass to be maintained [41]. Therefore, the use of this method is effective in the pontic area of the bridge [42].

Autogenous tissue graft. From a material point of view, the options available include the use of an autogenous subepithelial connective tissue graft harvested from the tuberosity area or the palate, a free gingival graft harvested from the palate, or a soft tissue substitute or a resorbable membrane that enhances closure of the soft-tissue wound [43-47]. These procedures are performed predominantly using a flapless approach or with a minimal coronal flap advancement, in order to preserve or gain keratinized tissue [48].

Membranes types. Resorbable and non-resorbable membranes with or without bone graft were effective on decreasing the alveolar ridge resorption after tooth extraction. Alveolar ridge preservation techniques have a more favorable outcome when a barrier membrane is used [11,49,50]. The principles of guided tissue regeneration it involves using a membrane to isolate the defect, thereby allowing space for osteoprogenitor cells to proliferate and differentiate along osteoblastic cells lineage. This increases the osteogenic activity in the defect area resulting in new bone formation [51].

A **new xenogeneic, porcine non-cross-linked bilayered resorbable collagen matrix** consisting of pure type I and III collagen has been designed for soft tissue regeneration [9]. The compact layer facing the oral cavity consists of compact collagen to fulfill the cell occlusive properties and allow tissue adherence and marginal adaptation as a prerequisite for favorable wound healing. In addition, the elastic properties of the smooth texture accommodate suturing to the host mucosal margins. The second layer consists of a thick, porous, spongy structure to allow tissue integration. This roughened surface is placed next to the host tissue to facilitate organization of the blood clot and to promote haemostasis and angiogenesis [52]. Clinical and histological results demonstrated revascularization, re-epithelization, and safe integration of the collagen matrix into the surrounding tissue without any signs of inflammation; this matrix was associated with greater thickness and width of the keratinized mucosa and a better color match than spontaneous healing [53-55].

CLINICAL RECOMMENDATIONS FOR ALVEOLAR RIDGE PRESERVATION

There are some clinical situations, in which minimizing alveolar ridge dimensional change is critical and dentists should take in considerations alveolar ridge preservation. These clinical scenarios are:

- Extraction sites in areas of aesthetic priority, both when an implant-supported and a tooth-retained (e.g. pontic site) restoration is planned.
- Extraction sites on which major ridge reduction is expected and may jeopardize implant placement, such as:
  - Sites presenting a thin and/or substantially damaged buccal bone plate.
  - Posterior sites exhibiting limited ridge height post-extraction, which may lead to implant proximity to the maxillary sinus or nerve structures.

In situations requiring that implant placement is significantly delayed after tooth extraction, such as, due to the young age of the patient [8].

CONCLUSION

Alveolar ridge resorption is unavoidable after tooth extraction and it represents a physiological process. It can lead to severe bone resorption, affecting the aesthetic outcome of further treatment. So, clinical intervention, such as alveolar ridge preservation are therefore needed in order to prevent alveolar bone resorption.

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