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3 D Augmentation Techniques in Atrophic Mandible: A Review

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ABSTRACT

Because of physiological alterations, alveolar ridge resorption has been thoroughly investigated. Alveolar ridge resorption, a progressive process that cannot be stopped, can happen for a variety of reasons. These aspects include whether a removable dental prosthesis is being utilized, biomechanics pertaining to the functional loading and occlusal forces, and local and/or systemic issues. Regardless of the source of resorption, the reduction in bone availability brought on by its unavoidable progression has a major effect on the bucco-coronal aspect and may make it more difficult to place an implant in the ideal location. so jeopardizing the achievement of acceptable function, appearance, and treatment longevity. A surgical procedure called "ridge augmentation" entails grafting both soft and hard tissues to expand the alveolar ridge's size beyond its initial, insufficient dimensions. Alveolar bone dimensions can be increased both horizontally and vertically using a variety of reconstructive procedures. Usually, these surgeries are performed in cases where there is no sufficient edentulous tissues to support a dental implant.

Keywords: *Bone grafting; Guided bone regeneration; Horizontal bone augmentation; Vertical bone augmentation*

Introduction

Dental implants are now considered the foundation of contemporary prosthodontic dentistry. However, ridge resorption remains the primary obstacle for the installation of dental implants. Although horizontal ridge augmentation is often reliable and effective, vertical ridge augmentation poses a substantial challenge in the realm of bone regeneration in implant dentistry(Fontana et al. 2011).

Multiple techniques have been described for vertical and horizontal ridge augmentation including distraction osteogenesis, (Froum et al. 2008) bone blocks, (Chiapasco, Brusati, and Ronchi 2007; Chiapasco, Zaniboni, and Rimondini 2007) ridge splitting(Donos, Mardas, and Chadha 2008) and guided bone regeneration.(Hämmerle and Jung 2003)

One challenging aspect of vertical and/or 3D-alveolar ridge augmentation, regardless of the technique used, is the considerable distance that the blood and cell supply originating from the periosteum must travel during the healing process. This is necessary to support the revascularization and integration of grafting materials positioned above the crest of the ridge.(Drake, Vogl, and Mitchell 2009). This factor also greatly influences the time needed for graft healing, which is reported to take up to nine months.

Ridge Augmentation

Ridge augmentation is a medical technique that involves grafting both hard and soft tissues to increase the size of the alveolar ridge beyond its original, inadequate structure. These surgical procedures are typically carried out when the edentulous area is deficient to accommodate a dental implant.(Tolstunov 2019)

Types of Bone Defects

Atrophic alveolar ridges with only one or two osseous walls remaining are classified as extrabony alveolar defects, while extraction sockets 3 or 4-wall defects are classified as intrabony alveolar defects. Extrabony vertical defects have a lower potential for bone regeneration and are more challenging to successfully augment than intraosseous defects that are surrounded by osteoconductive walls, which are an essential source of bone regeneration.(Misch et al. 2021)

These bone deficiencies or defects can be volumetric or 3D, vertical (VBD) or horizontal (HBD). The majority of alveolar bone deficiencies exhibit one or both of the directional components, with one typically predominating. Therefore, the techniques used in corrective surgical bone augmentation (BA) are typically horizontal bone augmentation (HBA), vertical bone augmentation (VBA), or both (3DBA).(Tolstunov et al. 2019)

Types of Surgical Augmentation Techniques

Numerous reconstruction techniques have been suggested to increase alveolar bone dimensions, both vertically and horizontally, in order to obtain an adequate ridge volume for prosthodontic rehabilitation and implant placement. These methods are Guided Bone Regeneration (GBR) using resorbable and non- membranes, bone block grafts either inlay, or onlay by autogenous, or allogenic bone blocks,Distraction Osteogenesis (DO), Ridge splitting or expansion, osteotomies of the ridge or the jaws, interposition graft or sandwich osteotomy technique or combinations of the above.(Chiapasco, Casentini, and Zaniboni 2009)

A. Block Bone Grafting (Onlay Bone Graft)

The BBG technique involves the use of a bone block that is completely separated from the patient's donor site. The harvested block may be either cortical (from the ramus) or cortico-cancellous (from the symphysis, anterior or posterior iliac crest). The bone block is then fixed to the recipient site using stabilizing screws. Occasionally, a particulate bone substitute, together with a guided bone regeneration (GBR) membrane, may be incorporated into a block transplant. Allogenic bone blocks are also available.(Tolstunov et al. 2019)

The block graft undergoes devascularization during the harvesting process. Block revascularization at the recipient site is needed for graft consolidation. Limited revascularization is linked to increased resorption reported in autogenous block bone transplants. Other complications include morbidity and infection at the donor site.(Cansiz et al. 2020)

B. Ridge-Split Expansion Procedures (RSEP):

Ridge-split expansion procedures involve horizontally ridge splitting to treat horizontal deficiency or vertically splitting (segmental sandwich osteotomy) to manage vertical deficiency. A particulate grafting material is used in the created compartment. Splitting of alveolar ridges of a dimension less than 3 mm is challenging and may complicate the use of this technique.(Tolstunov et al. 2019)

C. Distraction Osteogenesis (DO):

The DO approach is mostly used for treating big (5mm) VBD patients by applying a distractor to a bone section that has been cut. The technique is carried out gradually and dynamically, typically at a rate of 1mm per day for a period of 1-2 weeks. This leads to a gradual growth of the medullary bone compartment.(Tolstunov et al. 2019) Distraction involves not just the alveolar bone but also the expansion of the soft tissue envelope, which contains blood vessels. After bone fragments have been distracted and separated, they need to be stabilized for a period of three to four months in order to facilitate bone growth and the implantation of implants. An orthodontic tooth extrusion, whether rapid or slow, is a procedure used to achieve a vertical gain of 3-5 mm by applying tensile stresses to the tooth.(González-Martín et al. 2020) The enlargement of the periosteum is an alteration of the DO method. Some drawbacks of the technique include the requirement for a subsequent surgical procedure, the risk of infection, the lingual direction of distraction, and the possibility of dehiscence.(Kessler et al. 2007)

D. Inlay (Interpositional) Bone Grafting (Sandwich Technique):

In this procedure, a horizontal osteotomy is created with interposition of bone in the created gap in form of a sandwich.(Schettler and Holtermann 1977) The gap can be filled with autogenous or allogenic blocks, or with bone fragments with comparable results.(Felice et al. 2017) The osteotomy is done in the shape of a trapezoid with three sides using a fissure bur or piezoelectric device. To avoid the risk of the side wall of the alveolar bone being affected during transposition, it is important that the wider side of the trapezoid faces the crestal part. Mini-screws or mini-plates might be utilized to fasten the transposed portion. The crestal bone level of adjacent teeth and the available interarch space should be taken into account as the upper limit for transposing the osteotomized segment. Bone graft, whether in block or particle form, is employed to occupy the void, which will subsequently be substituted by fresh bone throughout the process of healing.(Felice et al. 2017)

E. Guided Bone Regeneration

This technique involves using different types of particulate grafting materials, which may be autogenous, allogenic, alloplastic, xenogenic, or combined. The use of a resorbable or non-resorbable membranes is mandatory in this

technique. It is used to treat bone deficiencies before placing dental implants or to address bone defects around existing implants. Non-resorbable choices include dense polytetrafluoroethylene (d-PTFE) and titanium-reinforced membranes for maintaining space and providing rigidity, together with tacks and screws for securing the membrane. Augmentation treatments that involve the use of a metal scaffolding device, like Ti-mesh, but do not rely only on cell guidance, should be referred to as "protective bone regeneration". Nonetheless, they are frequently grouped together as GBR grafting techniques. (Misch et al. 2021)

One of the most popular methods for maintaining alveolar sockets following tooth extraction or for horizontal and vertical defect augmentations is GBR.(Beitlitum, Artzi, and Nemcovsky 2010) In order to promote osteoprogenitor cells' proliferation and the formation of new bone tissue at the implant site, barrier membranes for GBR administration are essential in preventing cells from the surrounding epithelium and connective tissue from penetrating.(Retzepi and Donos 2010)

F. Bone Shell Technique (Khoury's technique)

Autogenous grafts remain the superior choice compared to other options due to their evident ability to promote bone formation, support bone growth, and stimulate bone regeneration. This is true even if alternative materials have been used in these treatments with different rates of success. In modern times, a minimally invasive technique is frequently employed to extract bone from a location close to where it will be transplanted. However, in order to treat significant skeletal defects or atrophies, it is necessary to obtain bone block grafts, which involves performing a second surgical procedure. According to the research, the mandibular retromolar region (external oblique ridge) is the spot within the mouth where bone can be harvested with the lowest rates of morbidity and problems.(Sittitavornwong et al. 2019) Bone shell technique has been devised to enhance the revascularization and regeneration capabilities of bones, offering numerous possibilities for bone reconstruction treatments, particularly for the treatment of combined bony defects. The bone obtained from this area consists mainly of cortical bone, which has poor revascularization qualities and regeneration capabilities.(Khoury and Hanser 2015)

Disclosure

The author reports no conflicts of interest in this work.

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