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Role of Hydroxyapatite graft and Barrier membrane in Alveolar ridge augmentation: A Review

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ABSTRACT:

Ridge augmentation, a critical procedure in modern dentistry, aims to restore the integrity and dimensions of the alveolar ridge after the extraction of tooth which resulting in loss of bone. Hydroxyapatite, a bioactive mineral renowned for its resemblance to natural bone, has emerged as a valuable material for enhancing ridge augmentation outcomes. Hydroxyapatite serves as an effective bone graft substitute and scaffold in ridge augmentation procedures. Its biocompatibility and osteoconductivity facilitate the regeneration of new bone tissue, promoting integration with the host bone. When applied within extraction sockets or over implant surfaces, hydroxyapatite mitigates bone resorption, preserving the alveolar ridge's structural integrity and facilitating successful dental implant placement. Furthermore, hydroxyapatite coatings on implant surfaces enhance osseointegration, contributing to long-term implant stability and functionality. In guided bone regeneration, hydroxyapatite combines with barrier membranes to create a conducive environment for bone regrowth while preventing soft tissue interference. Its porous structure facilitates cellular adhesion and vascularization, crucial factors for efficient bone formation. This abstract underscores the pivotal role of hydroxyapatite in ridge augmentation, underlining its potential to revolutionize dental implantology by offering a biocompatible and biomimetic solution for optimal alveolar ridge restoration.

Introduction

Dental professionals frequently deal with issues related to loss of alveolar bone. In cases of periodontal abnormalities, the ensuing bone defect has a cosmetic impact in addition to impeding prosthetic restoration.[1] In order to replace the missing bone and restore the alveolar ridge's contour, bone surgery is therefore carried out. For an implant to be successfully placed, there must be enough bone to surround it. Several methods have been developed and are being utilized to regenerate alveolar bone. One of the most common treatments performed in dental hospital's outpatient departments is guided regeneration, which has evolved due to the creation of replacement materials.[3] During surgery, a variety of grafting materials are employed. Alloplastic, autograft, xenograft and allograft are the four main types of bone grafting materials. Because it offers a solid scaffold for osteoconduction, autograft is still regarded as the gold standard in bone regeneration. Despite this, an autograft has certain drawbacks, such as the high risk of morbidity at the donor site, and a supply limitation.[3-5] Therefore, many types of allogenic, xenogenic, and alloplastic materials have been employed alone or in combination with substitute bone

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grafts for directed bony regeneration. Alloplastic (synthetic) grafting materials are mostly gaining popularity as a result of these issues.

Hydroxyapatite Graft and It’s Role

Van Meekeren repaired a sizable bone deficiency with calcium sulphate in 1892, which was the 1st recorded synthetic bone based transplant. Since then, a lot of bioceramic materials have been employed in humans in place of bone grafts. Hydroxyapatite (HA), which has a compound cosmetics and translucent design looking like those of bone, is the most often utilised bioceramic material of choice in grafting procedure for human bones.[6] Since they have been displayed to help bone in growth, HA and a few other ceramic materials (calcium-based) can be viewed as bioactive materials. Their osteoconductive qualities, which permit osteoblasts to appoint and migrate at the material surface, are related to their bioactivity. HA has also great biocompatibility. The hard and soft tissues of the mouth and jaws tolerate it quite well, and it has a lot of potential in the future. This research examines the material's numerous physical properties, including its solid and porous forms, its biological behaviour at various implant sites, and the surgical procedures used to implant it.[7] Numerous augmentation surgical methods can be employed to give sufficient bone volume to the solid inclusion of dental implants in the case of significantly resorbed alveolar ridge. These methods include vertical ridge augmentation, horizontal ridge augmentation, and extraction socket defect grafting. Compared to other grafting materials, they are less prone to complications and are more biocompatible.[8] For the purpose of fixing serious alveolar bone lacks for dental implants, various surgeries have been created. The doctor ought to utilize the best methodology to obtain the best outcomes at all measure of time. The ideal system ought to be direct, scarcely meddling, and have a generally safe of complications. Contingent upon the treatment type and administrator ability, Ridge-augmentation may be profoundly fragile. Not the entirety of the expanded volume, however, recovers into sound bone tissue. The wellbeing and amount of residual host bone have been viewed as more firmly related to implant endurance than the volume of grafted material. A procedure for remaking a one-wall defect that gets basically blood supply from the getting bone and little from the above delicate tissue is ridge augmentation that can be vertical or horizontal. Using a barrier membrane to prevent harm to the soft tissue during the flap elevation procedure. Therefore, only a small portion of bone substitutes—assessed to be inside 3 millimeter— could be rebuilt into reasonable bone tissue in the event that a sum of graft material is directed upward or on a level plane. Because of lacking blood supply, different spots would keep on being youthful woven bone for quite a while prior to being supplanted by granulation tissue mostly fibrous.. As a result, the recuperating system of augmentation ought to be entirely perceived for dental implantation to find success.[9] A ridge augmentation is a frequent surgery that is frequently done in the region of a missing tooth or teeth to help re-establish the regular shape of the gums and jaw that might have been lost inferable from bone misfortune because of a tooth extraction or for another explanation. The bone that encircles a tooth's root is known as the alveolar ridge. An empty socket is left in the alveolar ridge bone after a tooth extraction. Typically, this unfilled hole will naturally mend by enclosing in bone and tissue. Because there is no longer any stimulation for bone repair when the tooth is not there, the socket's prior height and width will eventually degrade.[10] Although it may be necessary for the placement of dental implants or for aesthetic reasons, rebuilding the alveolar ridge's original height and width is not strictly necessary from a medical standpoint. Bone supports the structure of dental implants, thus when there is inadequate bone, an implant cannot be successfully placed. This bone can be rebuilt to accept the implant with the use of ridge augmentation. For the restoration of alveolar ridge deficiencies either concurrently with or timed to implant insertion, guided bone regeneration has received extensive documentation. The phrase alludes to the employment of barrier membranes with the intention of "compartmentalising" to achieve the principle's fulfilment. Although it was later employed for implant site development, it was initially recommended for the restoration of the periodontium. In other words, the barrier membrane's role is to support bone formation while serving as a passive barrier to prevent the in growth of soft tissue.

Barrier Membranesand It’s Importance

Barrier membranes when used to supplement bone adhere to guide bone regeneration (GBR) concept. They are available in the form of non-resorbable and resorbable material. The primary function of GBR is to assist in clot protection and inhibit connective tissue and epithelial cells from relocating into the mending wound, favouring for osteogenic lineage cell localization. This material should have appropriate handling properties, an ideal degradation period, be cell-occlusive, permit space support, and be biocompatible. The GBR approach necessities to offer essential injury conclusion, angiogenesis, clump association, and dead space avoidance in order to be effective. It is therefore adequate space is essential below the barrier to allow not only cell movement but also the arrangement of fresh blood vessels. Larger deformities can need help from titanium mesh or bone grafts, among other materials.[11] Guided tissue regeneration (GTR) in the periodontium serves as the foundation for guided bone regeneration. The epithelial cells and connective tissues that make up the soft tissues of periodontium multiply and move about quite quickly. GBR tries to give to some degree shut climate to tissue development by protecting the delicate tissues from the bone imperfection utilizing a barrier film. To ensure that osteogenesis takes precedence and encourage the production of new bone, the cells with regeneration potential in the region of the bone deformity duplicate and separate to their fullest potential.[12] A unique bio-based and renewable substance known as polylactic acid (PLA) is manufactured from starchy plants like maize, sweet potato, and cassava as well as straws like cereal husks. For repairing bone deformities, PLA is an excellent membrane material. However, the PLA membrane quickly deteriorates, and the hydrolyzed PLA residue might result in localised irritation and abscess formation. Natural membranes have been replaced with synthetic PLA polymers because of their greater ability to induce osteogenic development. Lactic acid and hydroxyacetic acid, the two monomers—are randomly polymerized to creat PLGA. It’s a practical polymeric natural compound corrupts and has incredible biocompatibility, isn't harmful, and has great container and layer framing properties. It is oftentimes utilized in drugs, clinical designing materials, and contemporary businesses.[12] Using renewable plant resources like straws manufactured from cereal husks and starchy crops like maize, sweet potato, and cassava, polylactic acid or PLA is a unique bio-based and renewable biodegradable polymer. For the treatment of bone deformities, PLA makes an excellent membrane material. The PLA membrane, however, breaks down quickly, and the leftovers from PLA hydrolysis might result in localised irritation and abscess formation. As an alternative to natural membranes, synthetic PLA polymers have been produced because of their superior capacity to stimulate osteogenic differentiation. Lactic acid and hydroxyacetic acid are the two monomers that make up PLGA, which are haphazardly polymerized. It is a biodegradable, useful polymeric natural particle with exceptional biocompatibility, no harmfulness, and great container and film shaping capacities. It is generally utilized in drugs, clinical designing materials, and contemporary businesses.[13] A synthetic polymer called PCL is renowned for its biocompatibility and superior mechanical attributes. PCL has a substantially lesser cell affinity than PLGA. However, PCL has the advantage of minimising early scaffold fracture thanks to its superior mechanical characteristics. According to a research, silica nanoparticles (Si-NPs) can significantly enhance the mechanical and osteoconductive capabilities of electrospun PCL membranes. PCL can be changed to work with various barrier membranes because it has high mechanical qualities. For instance, the PCL reticulation created by over melt electro-writing can mechanically assist progenitor cell differentiation and regeneration in addition to delaying hydrogel breakdown and preventing soft tissue invasion.[14] A biocompatible polymer that can be degraded by bacteria is PEG.PEG is simple to produce and makes a great matrix and scaffold for various bone replacements. Additionally, it tends to be mixed with various polymers to make pristine assortments of natural barrier layers. In a study it was observed that PEG implantation maintained barrier function in vivo for as long as 4 months. PEG membranes are thought to provide significant advantages for the alveolar ridge augmentation in lateral ridge deficits, according to various preclinical experiments. One year later in another study, PEG membranes and collagen membranes were used to restore peri-implant bone deficits. The major element of extracellular matrix is collagen. At particular cell adhesion locations, collagen possesses exceptional ability to regulate cell proliferation, differentiation, shape, and adherence. Collagen is one of the most often used barrier membranes because of its high biocompatibility and accessibility from many sources.

Collagen layer is one of the most outstanding pre-covering films that can invigorate the development of new bone when joined with development factors. The outer layer of the collagen film is more charming to osteoblasts than the Teflon film and energizes their development. Chitosan, also referred to as deacetylchitin, is chemically known as polyglucosamine (1-4)-2-amino-B-D glucose. It has high penetribility with good antibacterial and immunomodulatory movement, and properties of procoagulant wound mending so it is widley used for bone tissue engineering .The porous calcium phosphate-reinforced chitosan scaffolds can also employed as a bone substitution for dental fillings and bone healing. Additionally, lysozyme may break down chitosan in living things to produce natural metabolites that are completely absorbed by living things and are not poisonous. It is therefore preferable to employ it as a medication supported discharge specialist and to apply it in an arrangement of medication and development factor controlled discharge. A pure form of silk, a macromolecule produced by the spider (Nephila clavipes) or cocoon (Bombyx mori), can be transformed into a variety of biomaterials, such as membranes, porous scaffolders, gels, stitch materials, and non-woven networks. Silk fibroin (SF), an underlying protein that is available in silk, has a high level of biocompatibility and is less likely to be adversely affected by external substances. The synthesis of bone tissue has been widely studied using SF, a new biomedical material that possesses superior mechanical properties to collagen membrane and regulated disintegration.

Non-Polymer Barrier Membranes alloys of magnesium and magnesium

When contrasted to different orthopaedic degradable materials, breakdown of magnesium-based materials creates a local magnesium-rich environment that can, through multiple signal mediations, activate numerous signalling pathways. The environment has the power to promote bone regeneration, increase osteoblast adhesion rates, reduce osteoclast activity, and control osteogenic cell signal transduction. Magnesium alloy is effectively used and assimilated in the physiological climate and has relatively active chemical characteristics. Degradation of it may encourage calcium deposition. Early in the process of osteogenesis, the rate of osteogenesis is rapid.[13] Zinc assumes a critical part in various crucial natural cycles, including the metabolism of nucleic acids, signal transduction, apoptotic regulation, and gene expression. According to a study conducted in vitro, passivation caused the zinc corrosion rate to increase after 120 hours, with little to no impact on the surrounding cultures.[14] An ideal substance for use in medicine is zinc, which degrades at a rate halfway between that of iron and magnesium. Because it directly activates aminoacyl tRNA synthetase in osteoblasts, also increases cellular protein synthesis, zinc is essential for the development and mineralization of bone tissue. Somewhat similar presumptions have been made by different authors in the literatures in their studies.[15-18]

Conclusion

For periodontal bony deficiency, sinus augmentation, and ridge or socket preservation, autograft is still regarded as the finest bone grafting material. Although there were no significant findings in the research, HA bone replacement is a promising choice for bone grafts because it can bring down the high gamble of benefactor bleakness and cause less distress. Therefore, a better bone replacement with excellent qualities for the management of decision in alveolar ridge and attachment protection, expansion of sinus, and bony defects of periodontium, should be created to address the issues in grafting methods.

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