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Short Communication

Third generation barrier membranes - Role in periodontal regeneration

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ABSTRACT

The objectives of periodontal treatment are not only the control of periodontal diseases but the regeneration of periodontal tissue destroyed by such diseases. A number of surgical procedures to achieve these goals have been devised over the years. The rationale of Guided tissue regeneration is to impede apical migration of the epithelium by placing a membrane between the flap and root surface (preventing contact of the connective tissue with the root surface); cells derived from the periodontal membrane are induced on the root surface selectively and periodontal tissue regenerated. Over the years, the development of membrane technology has evolved significantly.

1. Introduction

One of the main causes of tooth loss in the world is periodontal disease, which damages the tissues that support and surround teeth. As periodontal disease worsens, bone, gingival tissues, and the periodontal ligament may be destroyed; this necessitates surgery for regeneration and restoration. Rebuilding alveolar bone, replacing damaged tissue, and reestablishing the tooth's functional connection to the surrounding tissues are the goals of periodontal surgery. Membranes, which act as scaffolds or barriers to direct the regeneration of these tissues, are an essential part of many periodontal surgical operations.

In order to improve tissue repair and encourage more effective regeneration, bioactive substances like growth factors, antimicrobial agents, and stem cells are also incorporated into membrane technology in recent years. In addition to enhancing therapeutic results, these advancements seek to lower the risk of complications and encourage quicker healing.

1.1. Barrier membranes

Barrier membranes in GTR have gradually changed since Millipore filters made of cellulose ester were used.While all of the many types of membranes frequently fulfill the fundamental function of optimizing the natural potential for regeneration by avoiding undesirable cellular infiltration, certain secondary, situation-specific functions are nevertheless dependent on the membrane's construction or material composition. In general, the composition of the barrier membrane can be divided into absorbable and nonabsorbable categories, as well as synthetic and nonsynthetic. The material source for synthetic/nonsynthetic and degradational interaction inside body tissues for absorbable/nonabsorbable are referred to by these categorization phrases. The operator will choose the membrane of choice for various clinical settings based on these broad characteristics, taking into account the advantages and disadvantages of each type of membrane. Membrane use has generally shown significant clinical benefits in the treatment of furcation and intrabony defects in a large number of clinical studies.[1]

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1.2. Third generation membranes

Third-generation membranes have emerged as the idea of tissue engineering has advanced. These membranes serve as barriers as well as delivery systems that release particular agents, like growth factors, adhesion factors, antibiotics, etc., at the wound site as needed or at the appropriate time to better coordinate and guide natural wound healing. In a nutshell, they can be divided into the following subcategories:

1.2.1. Barrier membranes with Antimicrobial activity

The most important element compromising the outcome is bacterial contamination of the regenerating wound. Among the variables that could influence the GTR result are the type of bacteria, their number, and the region of bacterial contamination on the GTR membrane. Numerous Gram-positive bacteria and periodontal pathogens are among the bacteria that are present on GTR membranes. The number of membrane bacteria has a negative correlation with clinical attachment gain and a positive correlation with gingival recession. Following a GTR procedure, a systemic antibiotic is typically recommended to lower bacterial contamination and avoid wound infection. The outcomes, nevertheless, are unpredictable.

In the presence of the oral pathogens Streptococcus mutans and Aggregibacteractinomycetemcomitans, it has been shown that adding amoxicillin or tetracycline to different GTR membranes may improve the attachment of periodontal ligament cells. Tetracyclines have been promoted as helpful supplements for the treatment of periodontal disease. Dog periodontal bone regeneration would appear to benefit from the addition of 25% doxycycline to a GTR membrane made of polyglycolic acid and polylactic acid. Tetracycline-loaded expanded polytetrafluoroethylene (ePTFE) membranes enhanced clinical attachment gain and decreased bacterial contamination when used in clinical settings. Their recently identified non-bacterial qualities, such as their anti-collagenolytic, anti-inflammatory, osteoclast inhibitory, and fibroblast stimulatory qualities, may further contribute to their demonstrated effectiveness.

Tetracylines therefore extended the time it took for collagen membranes to degrade; this characteristic can be used in specific clinical settings where it is preferable to keep the membrane in place for an extended period of time.

1.2.2. Barrier membranes with Bioactive Calcium Phosphate incorporation

Numerous research teams have investigated the impact of hydroxyapatite (HA) nanoparticles in electrospun matrices on in vitro bone tissue regeneration. Research on the membrane made by Liao et al. showed that adding nano-carbonated hydroxyapatite (nCHAC) enhanced the membrane's osteoconductivity and biocompatibility. This three-layered membrane had a transitional layer made of nCHAC/PLGA, a pure PLGA non-porous side that discouraged cell adherence, and a porous side that allowed cell development by containing nano-carbonated hydroxyapatite/collagen/PLGA. Additionally, the scientists showed that the addition of nano-apatite significantly improved membrane bioactivity and promoted early cell differentiation.[2]

1.2.3. Barrier membranes with Growth Factor release

Growth factors, also known as morphogens, regulate cellular activity and provide cells the push they need to differentiate and create matrix for growing tissue. Growth factors are crucial for tissue development and the healing process. They regulate the production and breakdown of extracellular matrix proteins and have an impact on angiogenesis, chemotaxis, and cell proliferation, as well as tissue repair and illness. They work by attaching themselves to a target growth-factor receptor's extracellular domain, which then triggers the intracellular signaling cascades. In preclinical and clinical investigations, a number of bioactive compounds have shown promising effects in aiding the healing of periodontal wounds. These bioactive molecules include PDGF, IGFI, basic fibroblast growth factor (FGF-2), TGF-1, BMP-2, -4, -7 and -12, and enamel matrix derivative (EMD) that have shown positive results in stimulating periodontal regeneration.

It was discovered that PLLA membrane loaded with PDGF-BB may improve the effectiveness of guided tissue regeneration in rat calvarial lesions. A sandwich membrane composed of collagen sponge scaffold and gelatin microspheres allowed for the controlled release of basic fibroblast growth factor (b-FGF), which quickly and successfully restored the periodontal tissues in beagle dogs. It was discovered that growth factors like TGF-beta could be added to alginate membranes that served as drug delivery vehicles after a system consisting of an alginate film and a poly(L-lactide) acid (PLLA) asymmetric membrane was developed. When examined in an in vitro model system, it was discovered that this system had maintained its biological activity. A hybrid alginate/nanofiber mesh system with recombinant bone morphogenetic protein-2 (rhBMP-2) delivery system was found to be effective in repair of critical sized segmental defect in rat model.[3]

1.3. Electrospinning (e-spinning) for membrane

For preparing membranes for periodontal regeneration, the e-spinning approach has shown a lot of promise. Biocompatible and biodegradable natural or synthetic polymers that often mimic the structure of the native extracellular matrix (ECM) are produced by E-spinning. Li et al. have shown that the nanofiber structure can promote cell adhesion and proliferation by cultivating various cells, including fibroblasts, cartilage cells, and mesenchymal stem cells, on PLGA and PCL nanofibrous e-spun scaffolds.[4]

1.4. 3D printed membranes

Using 3D printing technology, membranes that are specifically suited to each patient's need can be produced. This makes it possible to create membranes with particular forms and improved mechanical qualities. Benefits: The accuracy and efficacy of tissue regeneration are increased by the precise customization of membrane forms made possible by 3D printing.

1.5. Functionally graded multilayered membranes

It was suggested that multilayered barrier membranes be used to create a graded structure with structural and compositional gradients that satisfy local functional requirements by promoting bone formation and inhibiting the downgrowth of gingival tissue. In light of this, a functionally graded three-layered membrane made of PLGA, collagen, and nano-hydroxyapatite was previously reported using a layer-by-layer casting technique. In order to facilitate cell attachment, the membrane was developed with a smooth PLGA nonporous film on one side and an 8% nano-carbonated hydroxyapatite/collagen/poly (lactic-co-glycolic) acid porous membrane on the other. Multilayeringe-spinning was used to develop and create a new functionally graded membrane (FGM). The FGM is made up of a core layer (CL) and two functional surface layers (SL) that connect the epithelium (metronidazole, MET) and bone (nano-hydroxyapatite, n-HAp) tissues. Two composite layers made of a gelatin/polymer ternary blend (PLCL:PLA:GEL) encircle the CL's neat poly(d,l-lactide-co-caprolactone) (PLCL) layer.[5]

2. Conclusion

In order to maximize the regenerative capacity of periodontal tissues, membranes are essential instruments in periodontal surgery. These membranes serve as scaffolds and barriers that allow for the controlled repair of periodontal abnormalities, which improves clinical outcomes for tissue integration, alveolar bone restoration, and periodontal regeneration. There have been notable developments in periodontal membrane technology, including as the creation of bioactive, nanotechnology-enhanced, and antibacterial membranes. The outcomes and predictability of periodontal regeneration therapies have improved as a result of these advancements. The combination of growth hormones, stem cells, and 3D printing technology has the potential to completely transform our understanding of periodontal tissue regeneration as research into this topic progresses.

3. Conflict of Interest

None.

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