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Barrier Membranes used in Guided Tissue Regeneration - Advantages and Disadvantages

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Abstract: ***Guided tissue regeneration is defined as a principle of regeneration that uses a barrier membrane to eliminate the possibility of the growth of a particular type of unwanted, fast-growing tissue in the area of the defect and to allow it to be colonized by particular types of cells that have the potential to regenerate the desired slow-growing tissues. Barrier membranes are resorbable and non-resorbable. Non-resorbable ones used in practice are polytetrafluoroethylene (PTFE) and titanium membranes. The resorbable barrier mambranes are collagen-based and synthetic, the synthetic ones being polylactide, polyglactic (lactic and glycolic acid copolymer) and polyethylene glycol.***

1. Introduction

Guided tissue regeneration is defined as a principle of regeneration that uses a barrier membrane to eliminate the possibility of the growth of a particular type of unwanted, fast-growing tissue in the area of the defect and to allow it to be colonized by particular types of cells that have the potential to regenerate the desired slow-growing tissues. [1]. Barrier membranes are resorbable and non-resorbable. Non-resorbable ones used in practice are polytetrafluoroethylene (PTFE) and titanium membranes. The resorbable ones are collagen based and synthetic, the synthetic ones being polylactide, polyglactic (lactic and glycolic acid copolymer) and polyethylene glycol [2,3].

2. Aim

The purpose of this study is to describe and review the types of barrier membranes used in guided tissue regeneration in periodontology.

3. Materials and Methods

Articles related to the subject were searched in PubMed and Google Scholar databases. Articles only in English language, published from 1982 to 2019, were included. The search was performed using a combination of different keywords such as: "guided tissue regeneration", "periodontal regeneration", "membranes".

4. Results and Discussion

The barrier membrane used in regenerative therapy is intended to prevent the proliferation of gingival fibroblasts and epithelial cells in the regenerative cavity, as well as to provide space for the regeneration of slow-regenerating tissues [4,5]. It has been found that the results of the application of bone repair materials in combination with a barrier membrane are significantly better than the results of the application of bone repair material alone. [6]

Barrier membranes are resorbable and non-resorbable. Non-resorbable ones which are used in practice include polytetrafluoroethylene (PTFE) and titanium membranes. The resorbable ones are collagen-based and synthetic.

The serious disadvantages of the non-resorbable membranes (e.g. the need of second surgery) and the resorbable membranes (e.g. insufficient mechanical properties, poor resorption period) have led to studies of alternative membrane materials with the required properties [7,8].

In order to be clinically useful, the barrier membrane must have appropriate mechanical and physical properties that allow it to be inserted in vivo and prevent its collapse into the bone defect, which would reduce the success of the regenerative result (9). In addition, barrier membranes should not cause any inflammatory reaction (9,10,11,12,13,14,15). One of the most important features of the membranes is their mechanical resistance. Each membrane should perform its barrier function from 4-6 weeks for GTR (for slow-growing tissue regeneration) to 6 months for GBR [9, 16, 17].

The need to use bioactive and multilayer membranes is increasingly emphasized, not only in order to meet the basic requirements for adequate mechanical properties and the rate of resorption, but more importantly to deliver biomolecules (e.g. antimicrobial and growth factors) and / or steam cells to enhance regenerative potential [17, 18, 19, 20].

4.1 Non-Resorbable Membranes

a) Polytetrafluoroethylene - expanded (e-PTFE)
These are gold standard materials with excellent biocompatibility, leading to significant bone regeneration in numerous clinical trials. They are synthetic non-resorbable membranes that can be porous and non-porous [21]. Over the years, they have proven to serve as a physical barrier that guarantees the maintenance of space needed for regeneration [9, 12, 14, 22]. However, they are rigid and can lead to soft tissue dehiscence [24]. Another disadvantage is that a second surgery is required to remove them, suggesting additional pain / discomfort for the patient [17]. The mean percentage of bone defect filling with the e-PTFE membrane was 78 ± 50% [21].

b) Titanium-reinforced membranes
They keep the soft tissues covered so that they do not collapse and provide the volume intended for regeneration. It is concluded that the approach with these membranes is considered to be a predictable surgical procedure [23].

c) Titanium foil
100 µm thick and 3 µm perforations. The advantage of non-resorbable membranes is the provision of a barrier function for a long period of time and optimal time of regeneration processes and small bone volume loss. The disadvantage is the need for a second surgery to remove the membrane, and the need for the membrane to be fixed to the bone (with pins) during the first surgery, which complicates the technique [25].

4.2 Resorbable Membranes

a) Collagen membranes
Collagen membranes can be of different origin - pericardial, dermal, peritoneal, tendon, etc. Their advantage is that they have good tissue integration, rapid vascularization, biodegradation without foreign body response, poor immunogenicity, osteoblastic adhesion, and proven biocompatibility [14, 17]. There is no need for a second surgery as they do not need fixation to the bone. [16,28,29]. Despite the many advantages of collagen membranes, they also have disadvantages, such as loss of resistance under damp conditions (related to the period of effective barrier function), risks of disease transmission, lower mechanical strength and relatively rapid resorption [17, 26, 27]. In some cases, the placement of a barrier membrane in two layers is also required, complicating the procedure and increasing the risk of dehiscence of the tissues covering the membrane [24, 29, 30, 31, 32]. They are reported to be used in implantology, sinus floor elevation and lateralization of n. alveolaris inferior [33, 34, 35, 36]

The average bone defect fill rate for the resorbable collagen membrane was 92 ± 19% [21].

Synthetic resorbable membranes - Polylactide,
Polyglactic (lactic and glycolic acid copolymer),
Polyethylene glycol.

Polylactide and polyglactic membranes are no longer used because of the high rate of dehiscence of the covering tissues with subsequent graft infection.

Polyethylene glycol membranes (PEGs) have become commercially available as automix preparations that are applied directly to graft and surrounding tissues. Once applied, they move from a semi-liquid state to a solid gel state that adheres to the bone. The main disadvantage of PEG membranes is their extremely high cost.

Karring et al. determine that the barrier membrane must have the following properties: biocompatibility, lack of integration to the recipient tissues, easy clinical manipulation and, if possible, retention of the site required for tissue regeneration [37].

Today, one of the promising techniques is that of the Electronic Spinning (Modeling / E-spinning technique) of membranes used in GTR / GBR techniques. The three-dimensional structure of these electronically synthesized membranes contributes to their larger surface area, better mechanical properties and regulation of cellular functions leading to new bone formation in the defect [7,38].

Another alternative is functionally graded (structured) and multilayered membranes – (functionally graded and multi-layered membranes) - consisting of a core layer and two functional surface layers (composed of gelatin) interacting with bone (nanohydroxyapatite) and epithelial tissues [7]. The addition of nanohydroxyapatite to the membrane composition improves the biocompatibility and osteoproductivity of the membrane [39]. Many researchers have successfully incorporated tetracycline hydrochloride and metronidazole benzoate in various polymeric solutions in order to develop material with therapeutic (antibacterial) properties [40].

5. Conclusion

The study presented here shows that there are many different types of barrier membranes used in guided tissue regeneration. According to the literature reports, the guided tissue regeneration method shows different long-term results, depending on the technique and the materials used. The factors that contribute to the success of a method are still under discussion. However, it is clinically proven that the results of the application of bone repair materials in combination with a barrier membrane are significantly better than the results of the application of bone repair materials alone.

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