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Guided Bone Regeneration: Descriptive and Retrospective Study Between PRF Membranes and PTFE-e.

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REVIEW ARTICLE

ABSTRACT

After the dental extraction and removal of lesions, the reabsorption of the alveolar bone crest of the area is common and inevitable, which can lead to a dimensional change of the bone area in terms of thickness and height. To regenerate the lost bony amount, and to make possible the placement of implants with predictability, checking restoration of function and aesthetics, the Guided Bone Regeneration (GBR) is often necessary. The GBR consists of a surgical procedure in which membrane barriers are used, with or without bone grafts. It is based on the concept of osteopromotion, which includes the use of physical means (barriers) to promote a total sealing of a certain anatomical area, preventing external agents and mainly connective tissue from interfering with the osteogenesis process. This barrier is positioned in close contact with the resorbed bone, isolating the periosteum in the external part of the membrane. Nowadays in commerce, countless materials can be used as a barrier in GBR, however, the purpose of this study is to describe the effects of the PRF membranes and PTFE-e membranes, observing the characteristics of each and its properties through literature and scientific studies, being able to conclude its positive and negative effects on its actions on bony regeneration can be concluded.

Keywords: Bone Regeneration, Fibrin Rich Platelet, Polytetrafluoroethylene.

Regeneración Ósea Guiada: Estudio Descriptivo Entre Membranas PRF Y PTFE-e.

Resumen

Después de la extracción del diente y la eliminación de las lesiones, la reabsorción de la cresta ósea alveolar en la región es común e inevitable, lo que puede conducir a un cambio dimensional en la región ósea en términos de espesor y altura. Para regenerar la cantidad de hueso perdido y permitir la colocación predecible de implantes, restaurar la función y la estética, a menudo es necesaria la regeneración ósea guiada (GBR). GBR consiste en un procedimiento quirúrgico, en el que se utilizan barreras de membrana, con o sin injertos óseos y se basa en el concepto de osteopromoción, que consiste en el uso de medios físicos (barreras) para promover un sellado total de una determinada región anatómica, evitando que los agentes externos y principalmente el tejido conjuntivo interfieran en el proceso de osteogénesis. Esta barrera se coloca en estrecho contacto con el hueso reabsorbido, aislando el periostio en el exterior de la membrana. Actualmente en el mercado existen numerosos materiales que pueden ser utilizados como barrera en GBR, pero el objetivo de este estudio es describir los efectos de las membranas de PRF y las membranas de PTFE-e, observando las características de cada una y sus propiedades a través de la literatura. y estudios científicos, pudiéndose concluir sus efectos positivos y negativos sobre sus acciones en la regeneración ósea.

Palabras clave: Regeneración Ósea, Plaquetas Ricas en Fibrina, Politetrafluoroetileno.

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1. INTRODUCTION

The world of dentistry knows the benefits and results of guided bone regeneration (Rossi *et al*., 2022). The reconstruction of large bone deficiencies in the facial skeleton represents a major challenge for the dental surgical community and several factors and/or conditions can trigger significant loss of adjacent structures, such as trauma, tumors, congenital abnormalities and periodontal disease (Suárez *et al*., 2015; Solakoglu *et al*., 2020)

The Guided Bone Regeneration (GBR) principle arose through Guided Tissue Regeneration, which aimed to regenerate lost periodontal tissues resulting from inflammatory periodontal disease. This favored the proliferation of tissue cells that healed the wound with desirable tissue (Schmitz *et al*., 2000). Initially, the only material available for GBR was a membrane in PTFE that was later modified by inserting a titanium core to reinforce it and maintain the space for regeneration underneath (Rossi *et al*., 2022).

A major obstacle to successful bone repair and neoformation is the rapid formation of loose connective tissue. This soft tissue growth can prevent osteogenesis in a defect or repair area. There are few studies on the effect of loose connective tissue on osteogenesis. For GBR to occur, osteogenic cells must migrate to the region of the bone defect, such as osteoblasts and cells from the adjacent bone. At the same time, excluding the existence of cells that prevent bone formation, such as epithelial cells and fibroblasts, results in higher rates of osteogenesis than fibrinogenesis (Liu *et al*., 2014).

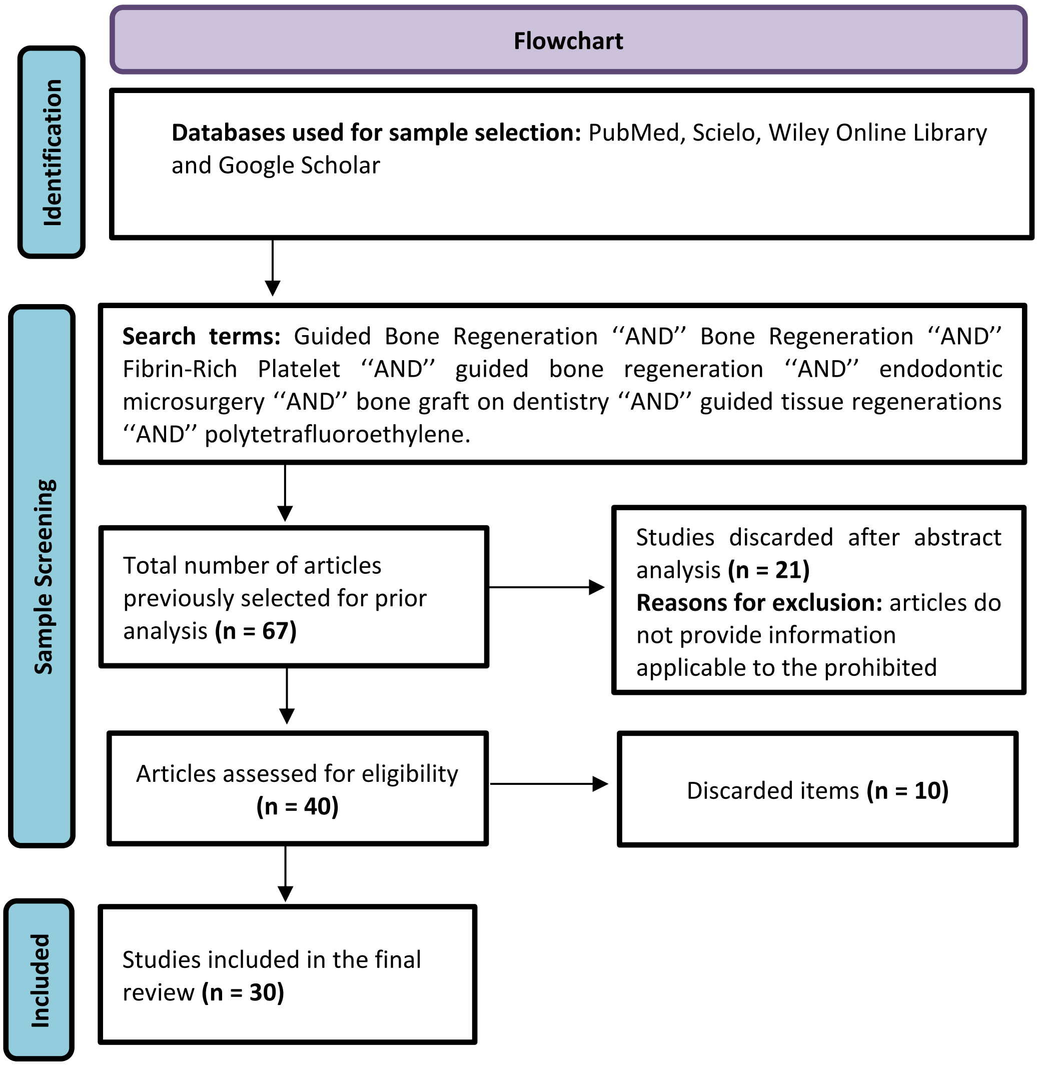
The primary objectives of GBR are successful bone regeneration in the defect area, with high predictability and low risk of complications. The secondary objective is a successful outcome with fewer surgical interventions (Buser, 2010). Otherwise, GTRs are commonly defined as separator membranes with regenerative and protective functions and come with multiple beneficial properties such as; promoting osteogenesis, inducing tissue regeneration, inhibition of infection, and upcoming inflammation (Mirzaeei *et al*., 2022).

This study aims to demonstrate how GBR works, expressing the basic principles, fundamental prerequisites and the materials of choice. With a descriptive focus on two materials used as membrane barriers for GBR.

2. METHODOLOGY

A review was carried out based on published literature and scientific articles published from 1994 to 2024, through the PubMed, Scholar Google, Wiley Online Library and Scielo databases, on the functioning and procedure of the Guided Bone Regeneration process, with PRF and PTFE-e membranes. The following descriptors were used: Guided Bone Regeneration ‘’AND’’ Bone Regeneration ‘’AND’’ Fibrin-Rich Platelet ‘’AND’’ guided bone regeneration ‘’AND’’ endodontic microsurgery ‘’AND’’ bone graft on dentistry ‘’AND’’ guided tissue regenerations ‘’AND’’ polytetrafluoroethylene.

Figure 1 - Flowchart presenting the Methodology applied.



Source: elaborated by the authors (2024).

3. RESULTS AND DISCUSSION

Historically, Murray, in 1957, mentioned that 3 fundamental conditions are necessary for bone regrowth: (1) the presence of a blood clot, (2) preserved osteoblasts and (3) contact with vital tissue, conditions which have not changed (Costa *et al*., 2016).

This principle of using a mechanical barrier to separate the loose connective tissue from the bone defect is now known as Osteopromotion. Characterization of the osteogenic process: Osteoconduction, Osteoinduction, and Osteogenesis. Once the graft and membrane have been placed, GBR follows a morphological sequence (Liu *et al*., 2014; Solakoglu *et al*., 2020).

In the first 24 hours after placement of an autogenous bone graft, the space between the barrier and the graft is filled with blood clots, which release growth factors such as platelets and cytokines, attracting neutrophils and macrophages. This clot is in turn reabsorbed and replaced by granulation tissue, which is rich in blood capillaries. These small vessels promote local nutrition, bringing mesenchymal cells capable of differentiating into osteogenic cells and later osteoid cells. These osteoids mineralize and serve to apposition lamellar bone. This procedure takes an average of 3 to 4 months after surgery (Liu *et al*., 2014).

According to Buser (2010), membranes can be divided into two groups: resorbable and non-resorbable. Reabsorbable membranes, as their name suggests, are absorbed by the body after a certain period. Non-resorbable membranes require a second surgical procedure to be removed.

The expanded polytetrafluoroethylene (PTFE-e) membrane was cited as the first membrane used in dentoalveolar regeneration. The PTFE-e membrane has been widely used since 1988, with all the prerequisites for osteopromotion, showing chemical and biological inactivity and no adverse tissue reaction. Its composition is expanded Teflon. It is biocompatible, relatively rigid to handle and promotes good maintenance of the space between connective tissue and bone tissue (Schenk *et al*., 1994).

Another material that has been widely used in GBR is the Fibrin-Rich Platelet Membrane (PRF). By collecting blood from the patient at the time of treatment, cytokines or growth factors are obtained from the platelets and thrombocytes through centrifugation. A highly dense, flexible and saturable fibrin membrane is obtained, releasing high quantities of platelets and platelet growth factors, stimulating angiogenesis, as well as serving as a physical barrier between bone and connective tissue, being stable for up to 28 days (Choukroun *et al*., 2017; Solakoglu et al., 2020).

3.1 BIOLOGICAL BASIS OF BONE REGENERATION

Bone tissue has a unique potential for regeneration. Bone is capable of healing local defects or fractures through regenerated tissue, or regenerating itself with a very similar structural organization, thus being a process of rememorization of osteogenesis. Bone generation, maintenance and repair are controlled by different cells: osteoblasts, osteoclasts and osteocytes, which are located within the cell matrix. A prerequisite for bone formation and survival is adequate blood supply, known as angiogenesis, which is not only important for the development part of bone tissue, but also for repair and maintenance (Schwarz *et al*., 2012; Elgali *et al*., 2017; Solakoglu *et al*., 2020).

Osteoblasts are large cells that form a single layer covering the entire endosteum and periosteum, where bone formation is active. They secrete osteoid matrix onto the bone surface, are responsible for synthesizing, assembling and mineralizing the bone matrix and are forged from the mesenchymal stem cells of the bone marrow. During life, the bone skeleton undergoes continuous remodeling, which is why there is constant bone repair and adaptation (Schwarz *et al*., 2012).

Osteoclasts originate from hematopoietic stem cells. Normal bone remodeling depends meticulously on a balance between bone synthesis and resorption, and any imbalance in this process causes alterations in this correct modulation of bone deposition and resorption. Osteoclasts have the main function of bone resorption (Schwarz *et al*., 2012; Solakoglu *et al*., 2020).

Osteocytes are formed through the induction of osteoblast cells during the repair process; they are located in cavities or gaps within the matrix. Their internal vitality is maintained through the organization of the supply in Volkmann channels and Harvesian channels (Natal, 2005; Aprile; Letourneur; Simon-Yarza, 2020).

3.2 ACTIVATING BONE REGENERATION

Any bone injury, be it a fracture, defect, implant insertion, or interruption of the blood supply, activates local bone regeneration through the release and production of growth factors and signaling molecules (Schwarz *et al*., 2012; Solakoglu *et al*., 2020). According to Aprile, Letourneur and Simon-Yarza (2020), GBR is one of the most common techniques for horizontal and vertical defect augmentations, or to preserve alveolar sockets after tooth extraction.

Bone is one of the richest sources of cells containing growth factors. Osteoinduction consists of bone formation in places where bone physiologically no longer exists. When osteoprogenitor mesenchymal cells are found in the area, close to bone tissue, they induce the deposition of osteoblasts in the region, resulting in bone formation. This process begins on day 4 and the newly formed bone is deposited on the pre-existing bone surfaces (Schwarz *et al*., 2012).

Bone tissue can regenerate itself, restoring its structure and mechanical properties. However, this capacity is compromised or fails if certain conditions are present at the site, such as a lack of vascular supply, mechanical instability, excessive defects; and competing tissues with a high proliferation capacity (Schwarz *et al*., 2012).

3.3 FUNCTIONS OF GRAFTS AND BONE SUBSTITUTES

Grafts have the function of filling defects, replacing portions of bone, facilitating or improving the repair of bone defects through osteoconduction, providing mechanical support for the membrane, stabilizing the blood clot and serving as a vehicle for growth factors, which then become incorporated.

For bone deposition to take place in the area to be regenerated, the graft must have three primary properties, or these factors must be promoted through their association:

- Osteoconductive Signs: Serve as a solid base for bone deposition.

- Osteoinductive Signs: Material containing proteins capable of stimulating the proliferation of progenitor cells to become osteoblasts.

- Osteogenic Signs: Material containing osteogenic cells (osteoblasts or pre-cursors capable of neoforming bone) (Schwarz *et al*., 2012).

3.4 TYPES OF GRAFTS

Autogenous or autologous grafts are obtained from the same individual and taken from another part of the body through a second surgical site. The most common donation sites include the mandibular ramus, chin, iliac crest or calvaria. Autogenous bone grafting is considered the gold standard material for reconstructing atrophic alveolar processes. When compared to bone grafts, such as allogenous and xenogenous, it has advantages in terms of resistance to infection, incorporation by the host, and no foreign body reaction, as it is the only one that has the three properties in a single material for the deposition of bone matrix at the site (osteoconductive, osteoinductive and osteogenic) (Liu *et al*., 2014; Fardin *et al*., 2010).

Allografts consist of a donor bone acquired from another individual of the same species. They are acquired from bone banks. However, they are rarely used as grafts in GBR due to their likelihood of rejection and disease transmission (Pinto et al., 2009).

Xenografts consist of bone mineral derived from animals or coral. They are currently widely used in GBR, especially those of bovine derivation, because the medullary bone is very similar to human bone. Xenografts undergo a process of sterilization against microorganisms, which leaves them free from the risk of disease transmission and immune responses from the patient receiving the graft (Schwarz et al., 2012).

Alloplastic grafts are prefabricated, fully synthetic materials. Examples include hydroxyapatite, calcium triphosphate and bioactive glass. They are rarely used in GBR, but are well used in prostheses for functional rehabilitation (Schwarz et al., 2014 and Fardin *et al*., 2010).

3.5 GUIDED BONE REGENERATION

Guided Bone Regeneration (GBR) can be performed in different situations to preserve the surgical site by excluding soft tissue cells at the site, which will promote bone regeneration. The most common procedure performed in GBR is with graft materials, as it is difficult to perform a GBR procedure immediately after an extraction with the placement of membrane barriers. In the vast majority of cases, GBR is always carried out after the lesions, always with high rates of resorption that have already occurred. Because of this, GBR is widely used with bone graft materials. As bone is a relatively slow-growing tissue, fibroblasts and epithelial cells have the opportunity to occupy the space available with grafting more efficiently, and build up soft tissue much faster than bone is able to grow. Their main function is to prevent unwanted cells in the space filled under the clot through membrane barriers (Schwarz et al., 2012).

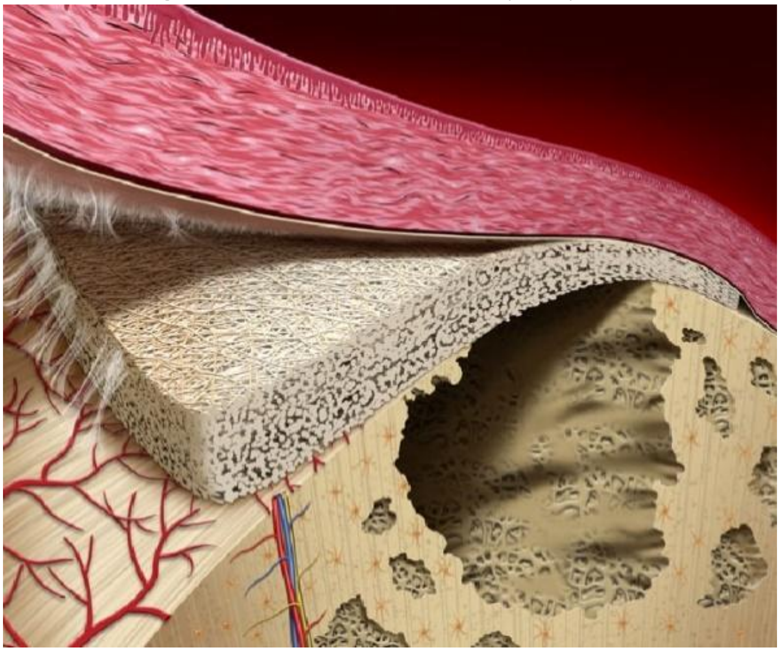
After extraction, the healing process takes 60 days. It begins with the formation of a blood clot and is then covered by connective tissue. Ideally, this alveolus should be preserved and the volume where the missing element was restored, but without this ideal additional treatment, resorption of the alveolar bone crest is inevitable and ends up generating changes in the alveolar dimensions of that site. These changes in dimensions are usually a loss of 1.5 to 2mm in bone height and a loss of 40 to 50% in thickness within 6 - 12 months of extraction. The highest rate of resorption occurs in the first 3 months, continuing to 11% loss over 5 consecutive years (Liu et al., 2018).

During the first 24 hours, after the graft is placed in the bone defect and the membrane barrier is present, the area is filled with blood clot, which promotes local nutrition with growth factor cells, such as platelets and cytokines (IL-8), attracting macrophages and neutrophils to the site. The clot is absorbed and replaced by granulation tissue, rich in blood capillaries, a process known as “Angiogenesis”. These capillaries carry osteogenic cells which will be deposited of the osteoid matrix and gradually reinforced by lamellar bone and later replaced by compact cortical bone (Schwarz et al., 2012; Elgali et al., 2017).

3.6 MEMBRANE BARRIERS

The principle of physically excluding an anatomical site for tissue regeneration has been used in neurosurgery since the mid-50s. In reconstructive bone surgery, a barrier is placed to prevent the invagination of connective tissue in bone defects. The membrane is positioned in direct contact with the surface of the surrounding bone tissue, keeping the periosteum on the outer surface of the membrane. The muco-periosteal flap is repositioned and sutured, creating a space conducive to bone regeneration (Figure 2) (Bornstein et al., 2009; Elgali et al., 2017).

Figure 2 - Illustration of the bone principle of GBR.



Source: Elgali et al., (2017).

Membranes must have some essential requirements to act as a passive physical barrier: biocompatibility, occlusive properties, space creation capacity, tissue integration and ease of use. In addition to having these properties, membranes must predictably promote bone regeneration, i.e. without side effects. The ideal physical property of the material used as a biological membrane is that it allows correct modeling of the grafted material. It must be resistant so that there is no deformation or spring effect, and after being positioned it must not dislocate facially (Costa *et al*., 2016).

3.7 TYPES OF MEMBRANES

The membranes used in ROG, accompanying the use of bone grafts, can be classified as Resorbable or Non-Resorbable. There are several types of non-absorbable membranes on the market, such as High-density Gore-tex™, Cytoplast™ GBR-200, Cytoplast™ Ti-250, among other brands, and the resorbable membrane proposed in the work, PRF (Costa *et al*., 2016 and Bisegna, 2013).

3.7.1 EXPANDED POLYTETRAFLUOROETHYLENE MEMBRANE (e-PTFE)

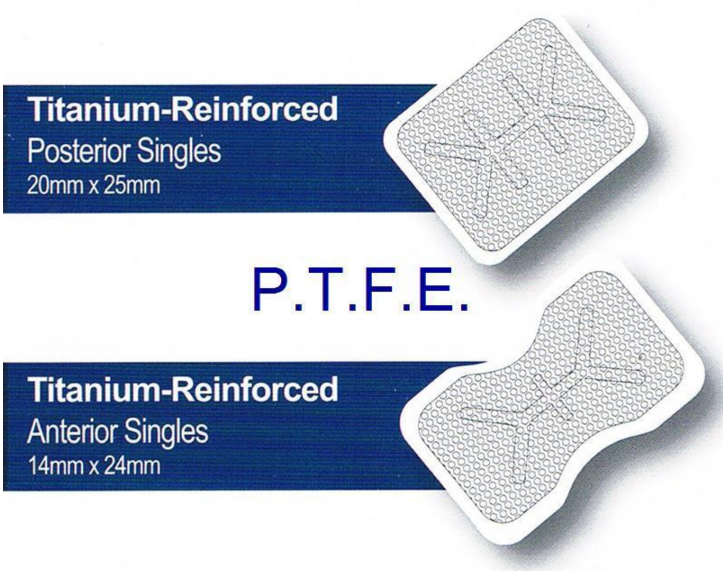
The expanded Polytetrafluoroethylene membrane was developed in the late '60s, its material is made of synthetic fluoropolymer, which consists of the union between carbon and fluorine, non-biodegradable and biologically inert. These properties give PTFE-e a certain rigidity with slight flexibility. In the 1980s and 1990s, PTFE-e membranes were the standard material used in ROG, being considered a "Gold Standard" material at the time. Initially tested in rats and primates, the beneficial effects of its use in GBR could be observed (Rakhamatia *et al*., 2013;).

PTFE-e membranes have excellent biocompatibility, providing adequate cellular occlusion, which consequently maintains the grafted space, creating conditions for osteogenic cells to populate the bone defect area. According to conducted studies, bone apposition can be observed within a period of 3 to 6 months, with satisfactory gains in bone dimensions, requiring its removal after complete GBR. (Dahlin *et al.*, 2010).

Furthermore, in concordance with Aprile, Letourneur and Simon-Yarza (2020), when compared to PTFE alone, titanium-reinforced PTFE could provide superior stability of the material for some types of bone defects, such as in supracrestal bone defects and sites with buccal dehiscence. It has also been proposed as an alternative to PTFE in cases involving advanced bone loss, due to increased provision of space.

PTFE-e membranes can also be reinforced with titanium, which has a "tent effect" characteristic, as they are capable of maintaining sufficient space without the addition of material to fill the area, and they can also be fixed with small metal screws. The main difficulty with membranes that do not have reinforcement is maintaining the space, but reinforced membranes have the disadvantage of the high cost of the material (Figure 3) (Kim *et al*., 2023).

Figure 3 - PTFE-e membrane, for the posterior and anterior regions, respectively.



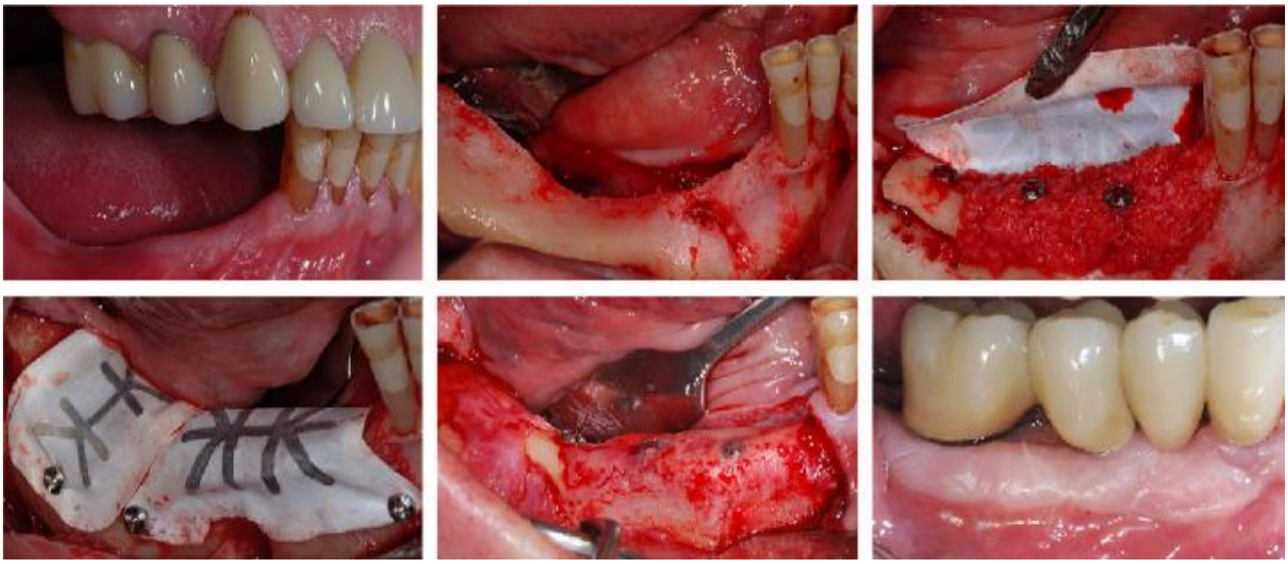
Source: http://www.dentalquirurgics.com/articulo_membrana-ptfe-no-reabsorbible-medipac.

Its osteopromotion potential lies in its structural rigidity, providing good cellular occlusion, and preventing fibroblasts contained in the connective tissue from making direct contact with the bone defect. However, this structural rigidity can end up being a negative point considered in some cases. There are reports of exposures due to wound dehiscence, leading to direct contact of the membrane with the interior of the cavity, compromising the graft area due to bacterial contamination, and leading to the failure of GBR. Depending on the region where the membrane is positioned, or due to a lack of soft tissue for coverage, or very thin gingival tissues, they become more prone to membrane exposure. (Bornstein *et al*., 2009; Elgali et al., 2017; Kim *et al*., 2023).

Regarding their presence, when exposed to the oral cavity membrane, they serve as a means of culture and passage of microorganisms to the interior of the area with skeletal function, committing to their occlusive capacity and allowing inclusive migration of conjunctival tissue cells to the interior of the region, thereby initiating local osteopromoção (Bornstein et al., 2009; Elgali et al., 2017; Ravi; Santhanakrishnan, 2020).

The high cost of PTFE-e membranes and the need for a 2nd intervention to relieve them (Fig. 4) must be taken into consideration because this is not reabsorbed, increasing morbidity and, as a result, the treatment's value (Tripplet et al., 2001; Elgali et al., 2017; Solakoglu et al., 2020).

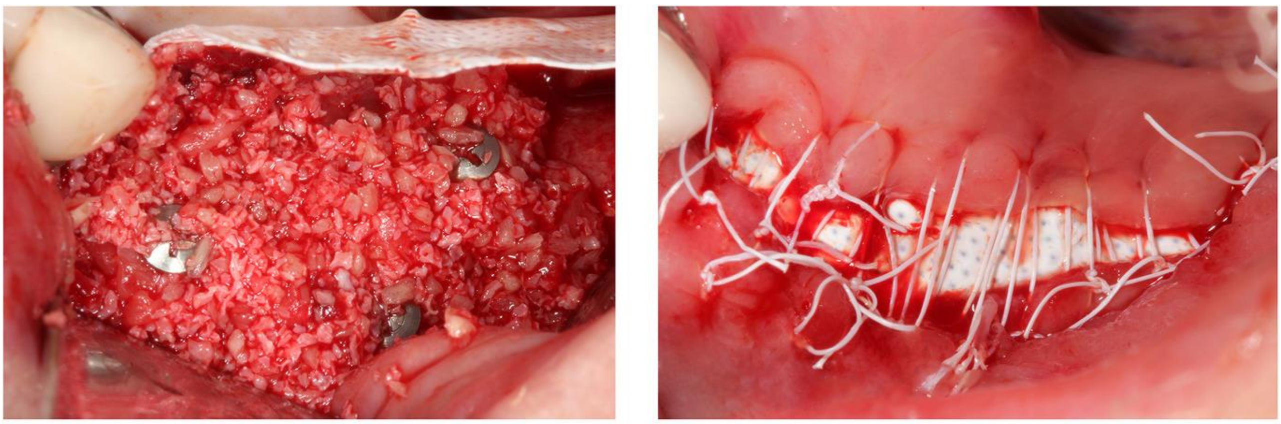
Figure 4 – Sequence of placement of the e-PTFE membrane, from the first surgical stage, its implantation, to the second surgical stage, its removal



Source: Elgali et al., (2017).

Recently, a case report was performed by Soldatos *et al*., (2022) to execute a vertical ridge augmentation around dental implants with PTFE membrane to correct previously failed augmentations was successfully carry out, as shown in **Figure 5**, respectively.

Figure 5 – A dense PTFE membrane was placed on the lingual aspect, and the mixture of bone grafting material was placed on top of the tenting screws (**A**). The site was sutured with 4-0 PTFE single interrupted and horizontal mattress sutures and left to heal in a secondary intention (**B**)



a b

Source: Soldatos *et al*., (2022).

Azhar *et al*., (2022) debate that the guided bone regeneration (GBR) technique is employed for ridge alveolar augmentation. The horizontal and vertical augmentation ridges, which impact implant resistance, have also been treated with the GBR approach. A membrane material is required in the GBR procedure to stop non-osteogenic cells from penetrating the wound and preventing the development of new bone. Typically, non-resorbable membranes like titanium mesh are used in the GBR procedure to augment bone vertical dimension volume (Azhar *et al*., 2022). To improve healing and bone regeneration, titanium mesh can be coupled with several membranes, including polytetrafluoroethylene (PTFE) membrane (Azhar *et al*., 2022; Kim *et al*., 2023).

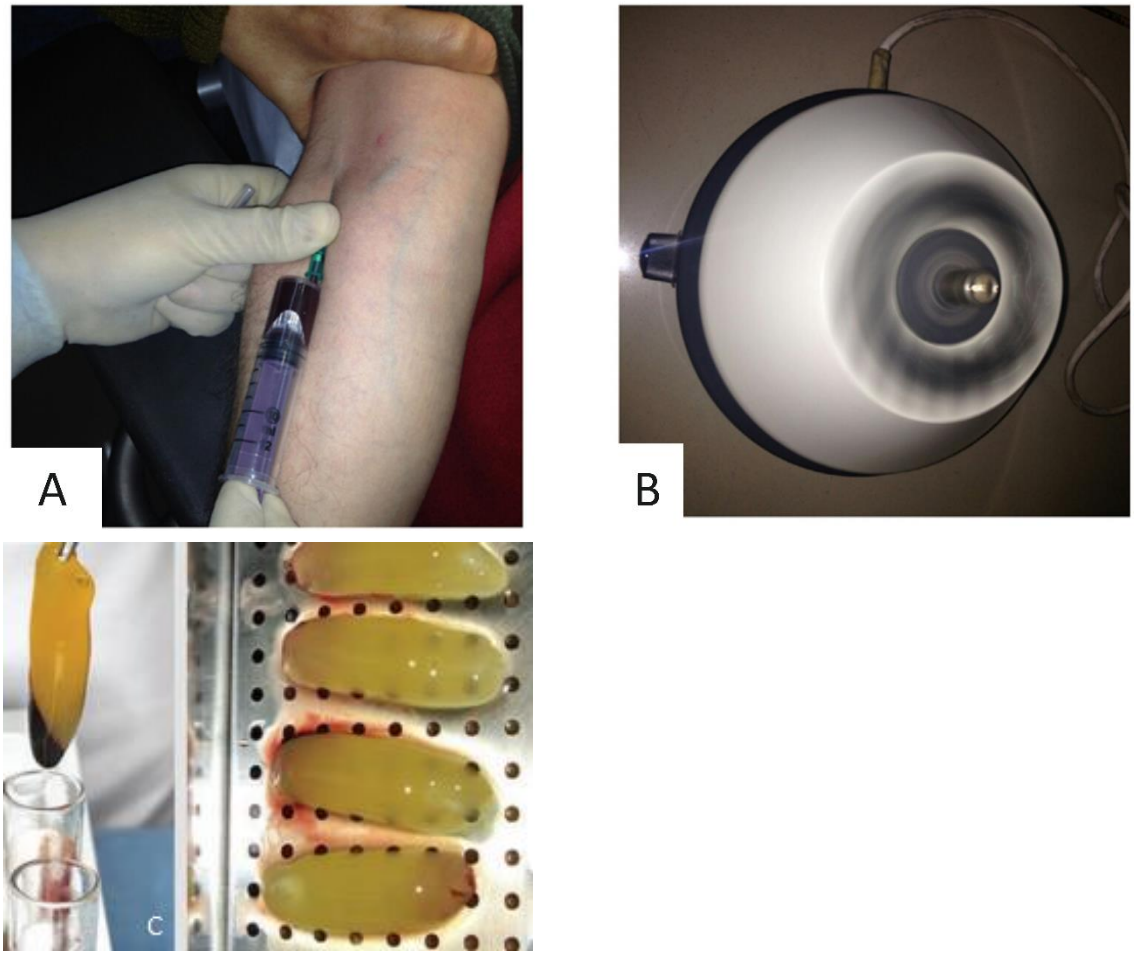
3.7.2 FIBRIN-RICH PLATELET MEMBRANE (PRF)

Due to the constant search to accelerate Bone Regeneration and minimize the complications that could occur, research was initiated into blood cells and their applications in bone defects. It began with PRP (Platelet-Rich Plasma), evolving into the second generation of platelet aggregates, Platelet-Rich Fibrin (PRF), which is fully resorbable, highly dense, flexible and suturable, releasing high amounts of platelets and platelet growth factors, stimulating angiogenesis and the constant release of growth factor cells for up to 28 days (Choukroun *et al*., 2017; Ravi; Santhanakrishnan, 2020).

Leucocyte and platelet-rich fibrin (L-PRF), a 2nd generation platelet concentrates, with, compared with whole blood, a 20-fold higher concentration of platelets and leucocytes entrapped in a strong 3-D fibrin network, releases all factors mentioned above in a sustained manner for 7–14 days. L-PRF also has antibacterial properties exhibiting strong activity, comparable with gentamicin and oxacillin, against methicillin-susceptible *Staphylococcus aureus*, methicillin-resistant *Staphylococcus aureus* and even *Escherichia coli*. (Pinto *et al.,* 2024)

Platelet aggregates were created to accelerate tissue healing by concentrating their cells with growth factors. They are obtained by collecting blood (10 ml) from the patient himself. This blood is centrifuged at 2,700 to 3,000 rpm for 12 minutes (standard time), separating the PRF from the other blood components. The red blood cells are in the lower portion of the tube, the platelet-poor blood plasma is in the upper part, and the fibrin-rich platelets are positioned in the center of the tube. No material is added to the collected blood, and coagulation occurs simultaneously with the separation of the blood components, which promotes consistency in the PRF (Figure 5) (Miron et al., 2017).

Figure 6 – (A) Blood collection; (B) Centrifugation of the collected material; (C) Fibrin matrix after centrifugation.



Source: A & B: Dar et al., (2016). C: Choukroun; Miron (2017).

PRF contains a strong, yellowish, opaque natural fibrin matrix. Its cells contain: transforming growth factor beta (TGF-beta); insulin-like growth factor 1 (IGF-1); vascular endothelial growth factor (VEGF); fibroblast growth factor (FGF); epidermal growth factor; platelet-derived growth factor (PDFG). These cells stimulate collagen production and accelerate the healing process of soft tissue and new bone formation (Cortese et al., 2017; Ravi; Santhanakrishnan, 2020).

Its biological effects consist of: Angiogenesis; its endothelial growth factor cells stimulate microvascularization. Mitogenesis; endothelial marrow stem cells promote rapid cell migration, when in contact with bone tissue, stimulate the formation of pre-osteoblastic cells, when in contact with connective tissue, stimulate the formation of fibroblasts. Control of the inflammatory process; through the degradation of fibrin, it controls the inflammatory process through the release of macrophages and neutrophils, releasing several cells derived from Interleukin (Shah et al., 2017; Ravi; Santhanakrishnan, 2020).

Zhang et al., (2018), demonstrated the action of PRF as a membrane barrier adhered to the graft region and gingival tissue, using PRF obtained from a modification in the blood centrifugation time, in 39 patients who lost teeth in the anterior region of the maxilla. The results obtained were satisfactory bone neoformation of 1.5 mm in thickness on average in the anterior region of the maxilla, reduction in postoperative pain (after 24 hours), improvement in the coloration and inflammation of the mucosa from the 3rd day after the surgical procedure, and satisfactory healing of the soft tissue on the 7th day.

3.8 CURRENT GENERAL CONSIDERATIONS

Schneider *et al*., (2013) carried out a clinical case study in patients who also had implant fenestration. In this study, 40 patients underwent treatment with implant fenestration. In the study by Summer, the percentage of bone formation in the others was 89.6% bone regeneration, and in Schneider, an average vertical bone increase of 5.5 mm was observed in cases where PTFE-e membrane was used and an increase of 5.1 mm in vertical height in procedures performed. In both studies, a 6-month healing period was allowed before removing the e-PTFE membrane. Greater maintenance of regenerated bone was observed after the ROG procedure, and both studies showed positive results after placement of the e-PTFE membrane in patients with fenestration.

With a retrospective view, in 2008, Rocchietta *et al*., carried out a comparative study between autogenous grafts, in a particulate block, both covered by e-PTFE membrane and atrophic jaws for implant placement. Ronda et al., in 2015, also carried out a clinical study on bone graft placement, making a comparative study between autogenous graft and xenograft in atrophic jaws. Rocchietta observed an average growth of 5.03 mm and Ronda an average growth of 5.49 mm of vertical gain in the dense e-PTFE membrane group and 4.91 mm in the e-PTFE membrane. Recent studies developed by Azhar *et al*., (2022) and Kim *et al*., (2023) confirm that this technique is improving.

The studies demonstrated that GBR in atrophic jaws with the use of autogenous and xenograft grafts have a good prognosis and good bone repair at the site with the use of the e-PTFE membrane, both in its conventional form and in its variable, which is the dense form of the membrane (Kim *et al*., 2023). In addition, bone regeneration is largely related to osteoimmunology, a new field that focuses on the interactions between bone and the immune system. Understanding these interactions can help in developing new treatments for bone diseases and injuries (Kim *et al*., 2023).

Rakhamatia et al., (2013) stated that e-PTFE membranes have the advantage of excellent biocompatibility and good space maintenance in small defects, making it possible to obtain significant bone regeneration in a period of 3 to 6 months, in addition to being relatively rigid to manipulation. However, for Jung et al., (2009), Dimitriou et al., (2002), Azevedo et al., (2014) present as the main disadvantage, as with any non-resorbable membrane, the need for a second surgical procedure to remove the membrane, in addition to its rigidity, which can cause dehiscence of the soft tissues and, as a consequence, the exposure of the membrane, which can lead to contamination of the surgical site, leading to failure of GBR.

The use of platelet aggregates in bone gain surgeries was initially developed due to their property of releasing growth factors (Rossi *et al*., 2022). The first generation of aggregates mainly includes platelet-rich plasma (PRP) (Marx et al., 1998) and plasma rich in growth factors (PRGF) (Anitua, 1999), but presents as one of the main differences between PRP and PRF membranes obtained from the gelation method (Rodrigues et al., 2015), thus PRF is more advantageous compared to PRP. The second generation of platelet aggregates, platelet-rich fibrin (PRF), was developed by Choukroun and his collaborators in 2001, to facilitate the obtaining and use of aggregates without the use of additives and make the technique less complex.

In studies conducted by Miron et al., 2017, the action of PRF in intraosseous defects in association with mineralized grafts demonstrated complete bone neoformation in the region (3rd molar extracted). Panda et al., (2016) obtained the same results in recent studies on extraction of impacted 3rd molars when PRF was associated with mineralized graft in the newly formed intraosseous defect.

When it comes to the association between different materials, Azhar *et al*., (2022) concluded that the GBR technique, which combines titanium mesh with PTFE and collagen membranes, can improve alveolar bone vertical addition, and the combination of titanium mesh with PRF can help the healing process move faster (Azhar *et al*., 2022).

Qi Li *et al*., (2013) in a clinical study, demonstrated the use of PRF as a membrane in 2 patients, in implants placed immediately after extraction of an upper central incisor (patient 1) and a lower 2nd molar (patient 2), applying GBR concomitantly with the placement of the implants, however, without using any type of bone graft. In 2016, Dar et al., carried out a clinical study, where 20 patients underwent cystic enucleation aged between 20 and 55 years and ROG with PRF without grafting in the bone defect sites. In both cases, the patients did not present complications during treatment and imaging monitoring was performed for 6 months, showing success in ROG, thus demonstrating the efficiency of regeneration in the absence of bone grafting.

FINAL CONSIDERATIONS

GBR is essential when there is a need to restore local bone gain. PTFE-e and PRF membranes have excellent positive properties, but also negative ones that can interfere with GBR. Choosing the ideal material for each case is essential.

PTFE-e is a consolidated material that has been on the market for 30 years and is a safe alternative, but it requires two surgical procedures and is expensive.

PRF has a good prognosis, in addition to initiating the process of bone matrix deposition and being less expensive, and can be combined with other membranes. However, further research and studies on this membrane are needed.

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