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The use of Polypropylene Membrane (Bone Heal™) in Guided Bone Regeneration: A Literature Review

O emprego da Membrana de Polipropileno (Bone Heal®) na Regeneração Óssea Guiada: Uma Revisão da Literatura

El uso de la Membrana de Polipropileno (Bone Heal®) en la Regeneración Ósea Guiada: Una Revisión de la Literatura

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Abstract

Currently, the search for more conservative and less invasive procedures is a major factor in Dentistry. In surgical procedures involving bone tissue, such as exodontia, milder and less aggressive techniques aim to preserve bone, regardless of the future installation of osseointegrated implants. Guided Bone Regeneration techniques can be used during tooth extraction or in procedures involving bone cavities. The use of the Bone Heal™ membrane has been widely explored, not only in exodontia with the future installation of osseointegrated implants, but also in other

indications for bone cavities or perimplant defects. The purpose of this article is to review the literature on the Bone Heal™ polypropylene membrane, presenting its advantages, benefits and techniques of use, as well as the pertinent characteristics of the surgical procedure involving bone tissue in Guided Bone Regeneration.

Keywords: Tissue Regeneration; Bone Regeneration; Oral Surgery; Tooth Extraction; Bioengineering; Implantology.

Resumo

Atualmente, a busca por procedimentos mais conservadores e menos invasivos é um fator preponderante na Odontologia. Em procedimentos cirúrgicos que envolvam o tecido ósseo, a exemplo no que ocorre na exodontia, técnicas mais brandas e menos agressivas objetivam a preservação óssea, independentemente da futura instalação de implantes osseointegrados. Técnicas de Regeneração Óssea Guiada podem ser empregados já na exodontia, ou em procedimentos que envolvam cavidades ósseas. O emprego da membrana Bone Heal® vem sendo amplamente explorado, não apenas em exodontias com a futura instalação de implantes osseointegrados, mas em outras indicações de cavidades ósseas ou defeitos perimplantares. O propósito deste artigo é revisar a literatura sobre a membrana de polipropileno Bone Heal®, apresentando suas vantagens, benefícios e técnicas de uso, além das características pertinentes ao procedimento cirúrgico envolvendo o tecido ósseo na Regeneração Óssea Guiada.

Palavras-chave: Regeneração Tecidual; Regeneração Óssea; Cirurgia Bucal; Extração Dentária; Bioengenharia; Implantologia.

Resumen

Actualmente, la búsqueda de procedimientos más conservadores y menos invasivos es un factor importante en Odontología. En los procedimientos quirúrgicos que afectan al tejido óseo, como la extracción dental, las técnicas más suaves y menos agresivas tienen como objetivo preservar el hueso, independientemente de la futura instalación de implantes osteointegrados. Las técnicas de Regeneración Ósea Guiada pueden utilizarse durante la extracción dental o en procedimientos que impliquen cavidades óseas. El uso de la membrana Bone Heal® ha sido ampliamente explorado, no sólo en extracciones dentales con la futura instalación de implantes osteointegrados, sino también en otras indicaciones de caries óseas o defectos perimplantarios. El propósito de este artículo es revisar la literatura sobre la membrana de polipropileno Bone Heal®, presentando sus ventajas, beneficios y técnicas de uso, así como las características pertinentes del procedimiento quirúrgico que involucra el tejido óseo en la Regeneración Ósea Guiada.

Palabras-clave: Regeneración Tisular; Regeneración Ósea; Cirugía Bucal; Extracción dental; Bioingeniería; Implantología.

Introduction

Surgical procedures involving bone tissue are very common in the dental clinic. Exodontia, excision of pathological bone lesions, resection of tumours or intraosseous lesions, installation of osseointegrated implants, curettage and scraping of perimplant lesions cause bone defects or cavities of varying size. The rehabilitation of these patients may depend on the quantity and quality of remaining bone tissue, and the installation of osseointegrated implants or the maintenance of dental elements is envisaged[1-18].

From this perspective, simple surgical procedures such as exodontia can become

traumatic and aggressive. In order to preserve the remaining bone, surgical procedures and techniques should be gentler and more subtle, avoiding more aggressive and brutal actions. Guided Bone Regeneration techniques can also be used in these surgical procedures, using biomaterials[1-18].

Several techniques, procedures and biomaterials can be used. The gold standard is still autogenous bone. However, due to the characteristics of the procedure in the oral cavity, biomaterials must have satisfactory procurement and handling characteristics. Thus, autogenous bone has the disadvantage of being obtained, determining the donor surgical bed in addition to the recipient surgical bed, characterising the morbidity of the procedure[1-20].

The Bone Heal™ polypropylene membrane has several benefits and advantages that make it a suitable biomaterial for intraoral surgeries[1-18,20]. Basically, it stimulates bone neoformation from growth factors originating in the blood clot, which initiate angiogenesis and osteogenesis, based on the principle of Osteopromotion[1-18,21].

The purpose of this article was to review the literature on the Bone Heal™ polypropylene membrane, presenting its advantages, benefits and techniques of use, as well as the characteristics pertinent to the surgical procedure involving bone tissue in Guided Bone Regeneration.

Discussion

Surgical procedure involving bone tissue

In a surgical procedure involving bone tissue, considering a bone cavity resulting from exodontia, installation of an osseointegrated implant, exeresis of a cystic lesion or even a bone defect after scraping an endoperiodontal or perimplant lesion, various biochemical and biophysical phenomena in the body are expected, based initially on the inflammatory process[1-18].

Clinically, retraction of the blood clot, invagination of the gingival epithelial tissue and resorption of the bone walls are expected. In cases of exodontia, greater bone resorption is expected in thickness than in height, due to resorption of the buccal and lingual/palatal walls. A reduction in the band of keratinized gingiva is also expected. This reduction, adjacent to teeth or peri-implants, jeopardises the protection provided by the mucosa to teeth and implants, contributing to the loss of both[1-19].

Pathophysiological Features of Bone Surgery Procedures

In a surgical procedure involving bone tissue - considering a bone cavity (alveolus, cavity or bone defect) - the blood vessels rupture and a blood clot is formed. This is made up of a network of fibrin, platelets and growth factors adhered to the walls of the bone cavity. Consistent angiogenesis then begins, with the aim of vascular proliferation. At this stage, in a common procedure, the invasion of epithelial cells, contact with salivary enzymes and oral microorganisms causes the physiological retraction of the blood clot. This characteristic is the precursor to resorption of the bone walls, whether in the socket, a bone cavity or a bone defect. To prevent the invasion of oral microorganisms, neutrophils, macrophages and salivary immunoglobulins play the role of the host's first line of defence[1-20].

Within 3 days, the bone cavity is filled with granulation tissue. Both the central and peripheral parts of the bone cavity are activated by angiogenesis. Angiogenesis involves the migration of macrophages, which

secrete cytokines and growth factors. Granulation tissue - this highly vascularised, collagen-rich connective tissue matrix - is made up of differentiated and undifferentiated cells, supplied by the periodontal ligament and endosteum. From the fourth day onwards, osteoblasts migrate to the region, filling the bone cavity. After 7 days, the process of osteoid matrix deposition by the osteoblasts begins, with subsequent formation of bone tissue. Bone formation is centripetal (i.e., from the periphery to the centre of the bone cavity), permeated by granulation tissue[1-19].

Within 45 days, the mature bone tissue is permeated by irregular trabeculae. After this, osteocytes are incorporated into the mature bone tissue. Within a few months, concentric lamellae with Havers and Volkmann canals are formed inside the newly formed bone tissue. Bone maturation involves the genetic information of bone production from the synthesis of bone morphogenetic proteins (BMPs) by platelets, as well as the differentiation of pluripotent cells into osteoblasts[22,23].

The newly formed bone, with adequate nutrition and maturation of the osteoid tissue, is viable for functional activities resulting from masticatory loads, considering an edentulous region that will receive osseointegrated implants[1-18]. Clinically, implantoprosthetic rehabilitation should take 4 to 6 months (mandible and maxilla, respectively), period considered for osseointegration[24]. It should be noted that epithelial tissue repair is shorter, with the bone cavity being covered after 21 days. This promotes isolation between the surgical site and the oral cavity[25].

Guided Bone Regeneration

Based on all the pathophysiological stages - haemostasis, chemotaxis, angiogenesis, extracellular matrix deposition and subsequent production and mineralization of the trabecular structure of bone tissue - the atraumatic surgical procedure should be considered. Maintenance of the blood clot inside the bone cavity and subsequent immobilization must be achieved for the best and most adequate bone repair[22,23]. In cutting-edge Dentistry, traumatic procedures can delay or limit bone repair, contributing to increased bone loss[26]. In the case of implant installation surgeries, even those based on reverse planning, it is also important to emphasise the need for advanced bone maturation[27,28].

In order to avoid or prevent the expected bone resorption, Guided Tissue Regeneration and Guided Bone Regeneration techniques and biomaterials can be used. However, more conservative and less aggressive techniques should still be emphasised in order to favour regenerative results[1-18].

There are various types of biomaterials - absorbable or non-absorbable - with different compositions. However, it is a common feature of most biomaterials that they are not exposed to the oral environment, but must be submucosal. Exposure to the oral environment directly implies contamination and subsequent infection of the surgical site, culminating in the loss of the procedure aimed at bone regeneration[1-18].

With this in mind, the Bone Heal™ polypropylene membrane was developed to solve this problem. Its main characteristic is the maintenance and immobility of the blood clot inside the bone cavity after the surgical procedure. As it is a plastic film made of non-absorbable and impermeable material (polypropylene), it can remain exposed to the oral environment[1-18].

The gold standard biomaterials for filling bone defects are still autogenous bone grafts. However, they must remain covered by a submucosal membrane. In addition, two surgical procedures must be considered: donor and recipient areas, which adds to the morbidity of the technique. These characteristics become disadvantages of its use. For these cases, the Bone Heal™ polypropylene membrane is also recommended[1-18,26,29,30].

The cells that make up the oral cavity have different rates of migration and proliferation. Epithelial cells proliferate and migrate quickly compared to bone cells. By using membranes to act as a mechanical barrier, the blood clot inside the bone cavity is maintained and preserved, preventing the invasion of these cells and the invagination of epithelial tissue. This feature reduces resorption of the bone walls of the bone cavity[20].

Bone Heal™ Polypropylene Membrane

Bone Heal™ is a biocompatible, non-resorbable, impermeable alloplastic film made up 100% of a polypropylene film. Designed to remain intentionally exposed to the oral environment, it has no porosity on its external surface, which gives it total impermeability, making it difficult for debris, food debris and dental biofilm to accumulate on its external surface. On its inner side, thanks to its slightly porous texture, the blood clot is adsorbed, keeping it in position inside the bone cavity[31].

The Bone Heal™ polypropylene membrane has been widely used in Guided Bone Regeneration, in alveoli after exodontias; in the installation of immediate implants; in sites with small bone fenestrations; in bone cavities after the enucleation of cystic lesions; in bone defects following the scraping of peri-implant lesions; after the explantation of fractured implants; in maxillary sinus lifts prior to the installation of osseointegrated implants; in the preservation of peri-implant mucosal tissue following the installation of osseointegrated implants[1-18,31]. Polypropylene is also used in other areas of health, such as orthopaedic and abdominal surgery in Medicine[1,2].

A biomaterial used as a barrier must, among other features, have some basic requirements: structural integrity; space maintenance; cell occlusivity; and ease of use. These features are contemplated by the Bone Heal™ membrane. The advantages and benefits provided by the Bone Heal™ polypropylene membrane are summarized in Table 1[31]. In addition, its internal surface in contact with the blood clot promotes the adsorption of osteogenesis precursor cells[1-18,26,29]. Local physiology (chemotaxis and angiogenesis) is enhanced by the use of the polypropylene membrane, favouring the body's own physiology in the synthesis and maturation of newly formed bone[26,29].

Table 1: Advantages and benefits of the Bone Heal™ polypropylene membrane[31]:

Advantages and benefits of the Bone Heal™ polypropylene membrane
Biocompatible, bioinert and impermeable by acting as a mechanical barrier
Malleability and flexibility: adaptation of the membrane to the bone defect
Diversity of indications
Diastasis are filled only with blood clot
Possibility of intentional exposure to the oral environment
No dimensional changes
Does not undergo hydration, adsorption or contamination
Easily sanitized by the patient while in use
No adherence to scar tissue
Easily removed
Gamma sterilized
No need for additional incisions and relaxants
No need for fixing screws
Does not deform under suture pressure
High level of predictability
Easy to use
No longer requires a learning curve for the dental surgeon
Does not require the use of another biomaterial, only blood clot
Registered with ANVISA (Brazil)
Low cost

The contraindications of the Bone Heal™ membrane are summarized in Table 2[31].

Table 2: Contraindications for the Bone Heal™ membrane[31]:

Contraindications to the Bone Heal™ membrane
Decompensated systemic disorders or diseases
Acute infectious processes
Poor oral hygiene, jeopardising the healing/repair process
Smoking patients

The Bone Heal™ polypropylene membrane comes in two models (Bone Heal™ and Heal Bone™) in different sizes to meet different surgical needs. Table 3 summarises the characteristics of both products[31].

Table 3: Characteristics of Bone Heal™ and Heal Bone™[31]:

	Bone Heal™	**Heal Bone™**
Biomaterial	Polypropylene	
Manufacturing	Different manufacturing process	
Inner face roughness	More pronounced	Less pronounced
Dwell time / deployment	More than 28 days	Up to 28 days
Resistance / Memory	+++	++
Available dimensions	30 X 40mm 20 X 30mm 15 X 40mm	

Despite its ease of use, some precautions should be taken, as summarised in Table 4[31].

Table 4: Cautions when using the Bone Heal™ polypropylene membrane[31]:

Care when using the Bone Heal™ polypropylene membrane
Single-use material
Do not use leftover cut-outs
Once removed from the packaging, it must be used within four hours
Post-surgical oral hygiene care: chlorhexidine digluconate 0.12% (avoid vigorous rinsing)
We recommend removing the polypropylene membrane in 7 to 14 days.

Technique for using the Bone Heal™ membrane considering the use of the Bone Heal™ membrane for extraction (Figure 1), for example, the relevant extraction steps must be carefully followed. The procedure must be cautious and subtle to avoid fracturing the alveolar walls and subsequent major bone loss[31].

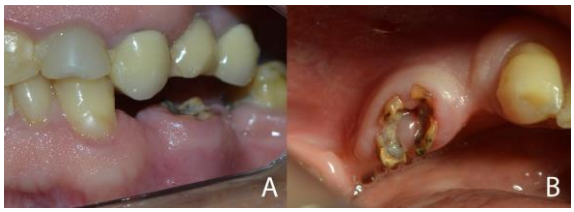

Figure 1: Fractured tooth 35, indicated for exodontia.

1. Exodontia properly performed, with abundant curettage, removing periapical lesions and granulation tissue (Figure 2);

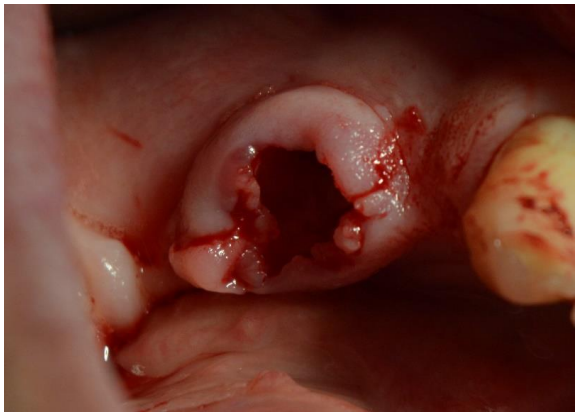

Figure 2: Exodontia performed, with abundant curettage, removing periapical lesions and granulation tissue.

2. Washing with saline solution;

3. Favour bleeding and clot formation;

4. Open the outer packaging and place the inner (sterile) packaging on the surgical field;

5. Cutting out and adapting the membrane to the desired shape of the surgical site/bone defect;

6. The barrier should completely cover the bone defect, extending about 2 to 3mm beyond the edges of the defect area;

7. Suture the flaps;

8. The barrier should preferably be exposed to the oral environment (tissue repair by second intention);

9. The suture of the flaps should not tension the gingival/mucosal edges of the surgical wound;

10. The sutures should only hold the barrier in place (Figure 3);

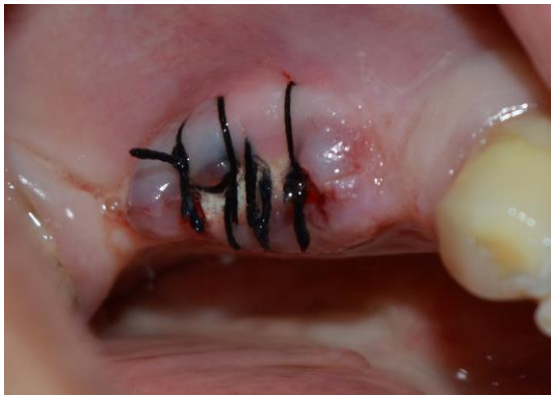

Figure 3: Bone Heal™ membrane below the sutures.

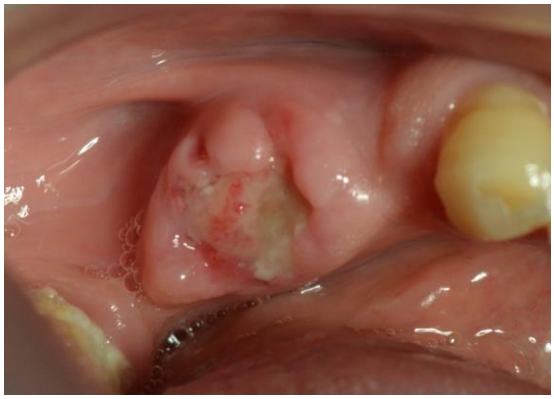

Figure 5: Removal of the barrier (14 days). Observe the presence of granulation tissue.

11. Usual post-surgical care;

12. Removal of the membrane and sutures: 7 to 15 days (Figure 4);

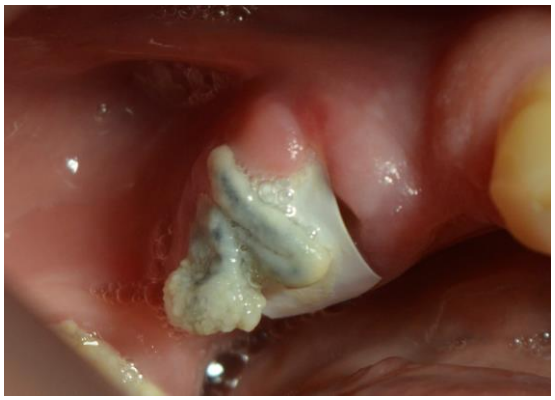

Figure 4: Post-surgical assessment (14 days): membrane and remaining sutures.

13. After removing the barrier, granulation tissue is seen covered by a slightly whitish pseudomembranous film (fibrin film): do not remove (Figure 5);

14. Discard the membrane.

Conclusions

The use of the Bone Heal™ membrane as a barrier helps maintain the blood clot inside the bone cavity, regardless of the origin that caused the defect. From this perspective, the post-exodontic socket, implant surgical bed, bone cavities following the enucleation of cysts or periapical lesions, or bone defects arising from the surgical scraping of peri-implant infections, can receive the installation of the Bone Heal™ membrane. Its use allows the bone regeneration process to take place through osteopromotion, reducing bone loss and favouring bone neoformation.

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