Review

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Regenerative endodontic therapy - bone materials and techniques. Review Part II.

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Abstract

The aim of this review is to summarize biological products - bone replacement materials and techniques for regenerative endodontic therapy. Bone grafting is a dynamic phenomenon. Successful transplantation involves graft placement, healing, incorporation, revascularization, and the formation of the desired amount of new bone. The techniques for regenerative endodontic therapy are described: apexification and apexogenesis; treatment of vital inflamed dental pulp while maintaining its vitality; treatment of chronic periapical periodontitis.

Keywords: regenerative dentistry, biomaterials, growth factors, tissue engineering, endodontics

Introduction

During application of the conservative approach in endodontic treatment, the pulp chamber and root canals are cleaned and filled with biologically inert substances, which does not preserve viable tissue. Endodontic treatment is currently developing with the introduction of regenerative endodontic therapy. This aims to replace damaged tissues, including dentin, root structures and cells in the pulpo-dentin complex via

biologically activated procedures (1,2). Regenerative endodontic therapy replaces affected tissues with vital and viable ones, both in the periapical periodontium and in the dental pulp, by stimulating the healing process or by placing biologically active substances (3,4,5).
Regenerative endodontic therapy is in fact tissue engineering. Tissue engineering is based on three main pillars: 1) cells/stem cells responsible for synthesizing new tissue matrices; 2) growth factors initiating the functions; 3) a biomaterial scaffolds needed as an extracellular matrix for cell differentiation and biosynthesis(6).
Regenerative endodontic therapy is achieved through the introduction of biological products. These are the blood plasma along with growth factors contained in the platelets, as well as some graft materials(7,8,9). Protocols for the production of various biological products are continuously being perfected (10,11,12). As a result, the possibilities of endodontic treatment are expanded, resulting in significantly reducing the time for regeneration of affected tissue (7).

Aim

The aim of this review is to summarise biological products (plasmotherapy, bone replacement materials) and techniques for regenerative endodontic therapy.

Bone substitutes

In the presence of bone defects, the use of bone substitutes is appropriate. Bone grafting is a dynamic phenomenon. Successful transplantation involves graft placement, healing, incorporation, revascularization, and the formation of the desired amount of new bone. Modern beliefs consider the bone graft as a biological structure. The goal is to replace and repair damaged bone structures. The filling of bone defects with bone substitutes is aimed at migrating cells to the replacement material until it is gradually replaced by new bone. But for the process itself, the mechanical stress during tissue processing, the tension during their cutting, contouring and remodelling, etc. are important (13). The types of bone substitutes (graft materials) are:
Autotransplants (autograft) materials -moved from one place to another to the same individual; allotransplants/allograft materials-tissue transferred between two genetically different individuals of the same species;
Xenotransplants (xenograft) materials - tissue of one species implanted in an individual of different species-bovine, equine graft-animal origin; coral origin; seaweed origin;
Synthetic (alloplastic) transplants-hydroxyapatite and tricalcium materials (14).
Allograft materials are considered complete. They are usually obtained from living donors by hip endoprosthesis surgery and removal of the femoral head. Block grafts with low mechanical strength and lack of osteoconductive potential (mineral component missing) are obtained. At the same time, this makes bone morphogenetic proteins more accessible, which determines a higher osteoinductive potential. It is available as granules and blocks - spongious and cortico-spongious (15).
Synthetic transplants based on hydroxyapatite and tricalcium materials are also of interest (15).
It is important to note that augmentation uses a membrane that acts as a placeholder in the area immediately below it and prevents the separation of blood coagulation from the walls of the defect. The membrane serves as a barrier against epithelial-connective tissue proliferation and promotes bone growth (16). As such, a membrane made according to the A-PRF and A-PRF + blood plasma protocols can be used (17).
In regenerative dentistry, graft materials play the role of a matrix or a scaffold, and through osteogenesis, osteoinduction, osteoconduction and osseointegration, they promote new bone formation (18).

Regenerative endodontic therapy

Regenerative endodontic therapy (RET) includes : 1. Apexification and apexogenesis (19); 2. Treatment of vital inflamed dental pulp while maintaining its vitality (1,20); 3. Treatment of chronic periapical periodontitis (17, 19, 21,22).

PRF, developed by Choukroun et al. is a biological skeleton that are well documented in regenerative procedures and is known to release high amounts of growth factors such as TGF-β, PDGF-AB or VEGF and matrix proteins such as thrombospondin-1, fibronectin and vitronectin (7). Its hard nature offers excellent processing properties and easy placement in tight spaces such as the pulp chamber or the dental apex (10).

Apexification and apexogenesis are clinical procedures part of regenerative endodontics. Carrying out endodontic treatment of teeth with incomplete root development is a challenge, as there is no apical narrowing and hermetic sealing of the endodontic space is almost impossible. The first attempts to restore apical narrowing were made by Nygaard-Otsby, Banchs and Trope and others (4, 23). Regenerative endodontics for the creation of apical narrowing is based on revascularization of apical tissues, blood supply to the periapical space, creation of a wound surface, and during the healing process forms apical narrowing (24). There are also numerous authors who prove the importance of plasmotherapy in the treatment of dental pulp diseases without damaging the periodontium of the tooth and for preserving the vitality of the pulp tissue itself (1,23).

Treatment of inflamed dental pulp while maintaining its vitality. In the presence of an initial inflammatory process in the dental pulp and establishing communication with it, classical endodontics recommends direct pulp coating in order to preserve the vitality of the dental pulp. However, the application of this method is too limited and uncertain. With the development of regenerative endodontic treatment, it is possible to keep the dental pulp viable by applying a membrane made of A-PRF blood concentrate onto the communication (even with defects larger than 1 mm) (25,26). Further research are necessary in this area.

Treatment of chronic periapical periodontitis. In chronic periapical periodontitis, the dental pulp is irreversibly damaged, yet the recovery of the periapical tissues is an important point. The unfavourable outcome of the treatment of this type of disease is associated with the loss of the tooth or teeth. At the same time, treatment of this condition is difficult, involving a lot of time and visits, with an uncertain result. Radical removal of the altered periapical tissues is possible through surgical intervention. This manipulation, however, is associated with pain, swelling and discomfort for patients. The use of blood plasma products in the process of surgical treatment of chronic periodontitis significantly increases the possibility of complete recovery of the affected periapical tissues. A rapid healing process, reduction of postoperative oedema, pain and discomfort is expected (26). A majority of the researchers indicate that in-depth clinical trials and comparison with established clinical treatment protocols are needed (27). What happens in the periapical tissues after surgery (apical osteotomy) by introducing PRF? Most authors note that the postoperative complaints are reduced - pain, discomfort and the healing recovery is shortened (18, 21, 22, 26). What is the difference with classical apical osteotomy regarding the restoration of bone tissue in the area of the periapical lesion? And is there a difference if the periapical lesion is repaired by placing graft material with platelet concentrate (A-PRF or A-PRF +) or only platelet concentrate without graft material? These questions are still awaiting answers.

In the treatment of periapical inflammatory processes, it is important to note that some procedures in root canal treatment are essential for regenerative recovery of periapical tissues. These are: Sodium hypochlorite solutions, EDTA solutions, Chlorhexidine solution, antibiotics, and Calcium hydroxide preparations. What is their significance for the purposes of regenerative endodontic therapy?

Irrigation with Sodium hypochlorite solutions has an antibacterial effect against the bacterial biofilm and effectively dissolves organic and inorganic tissues (27). The concentration of the solution is important for RET. High concentrations of Sodium hypochlorite - 5.25% - are known to have a cytotoxic effect on stem cells. For this reason, lower concentrations are recommended for the purposes of regenerative endodontic treatment (28).

Irrigation with EDTA solution is important as this medicine is a chelating agent which removes the smear layer during the process of regenerative endodontic treatment and has been shown to release growth factors from the dentinal matrix as a result of dentin demineralization (29). At a concentration of 17% it increases stored viable stem cells from the apical papilla. Its effect in final irrigation in uninfected root canals has also been proven (29).

Irrigationn with Chlorhexidine solution has a proven antimicrobial activity. It is important not to allow any reaction with other wash solutions by applying intermediate irrigation with sterile saline (27).

It is considered that Calcium hydroxide medications are the first choice when conducting regenerative endodontic therapy. The good antibacterial properties of the preparations based on an anti-inflammatory effect on the tissues, have been proven. As a result, they participate in the formation of mineralized tissues, including the differentiation of cementoblasts in the periodontal ligament and cementogenesis(18).

Other materials causing apexification are Tricalcium phosphate, osteoproteins, MTA and others (18,21).

The introduction of plasmotherapy, graft materials in regenerative endodontic therapy marks an important advance in dental medicine, as it is the implementation of tissue engineering for the treatment of endodontic diseases. Additional long-term clinical trials in this area are needed in order to detail and present both the positive qualities of the techniques and the precise indications for their application.

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