

Research Article

Biomaterials for Periodontal Regeneration: A Comprehensive Discussion of its Merits and Demerits

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Abstract

Treatment of periodontal diseases is becoming more prevalent and one of the treatment methods is to regenerate periodontal tissues. Over the period many biomaterials have been developed many of which are currently being used and more research is still in progress. Such a range of biomaterials choice makes it a challenging ordeal for Dentists to weigh the pros and cons of the popular biomaterials. This manuscript attempts to be a comprehensive document that discusses the merits and demerits of various biomaterials to aid in the decision making of biomaterial choice for periodontal disease treatments.

Key words: Dental Biomaterials, Periodontal Disease Biomaterials, Biomaterials for Intra-bony Defects.

Introduction

Periodontal diseases are one of the common dental problems among adults in the US population. According to the American Academy of Periodontology (AAP) it is defined as a chronic inflammatory disease that affects the gum tissue and bone supporting the teeth. 47.2% of adults aged 30 years and older have some form of periodontal disease and it increases with age, 70.1% of adults 65 years and older have periodontal disease [1]. It's well known that if not treated, it will lead to dental (tooth loss due to alveolar bone destruction) and medical complications (heart diseases ,aggravate/worsen existing systemic conditions like diabetes by raising its Hba1c level due to entry of oral bacteria in to blood stream). So, it is inevitable to treat periodontal diseases and there are many treatment modalities available depending on the nature of bone destruction and symptoms of periodontal diseases. This paper will specifically explore the biomaterials emerging and being used to regenerate periodontal tissue as one of the treatment options.

Calcium Phosphate

Advantages of Calcium phosphate- it has a similar composition to bone mineral. It will promote cellular function and has a bioactivity meaning it will form the bone like material when used for regeneration. As CP has a high affinity for proteins, it will act as ideal carriers for peptides, bone growth factors etc. So, once it is bonded with circulating bone morphogenic proteins, it will promote osteo-induction [2]. Also has osteo-conductive property [3]. All these properties combined make this material more suitable for tissue regeneration and it could be used in gene therapy, cancer therapy and osteoporosis therapy. There are no known adverse effects associated with using material.

Hydroxyapatite (HA)

Advantages – Like calcium phosphate, HP also has a similar composition to natural bone mineral [4]. When it is implanted, it chemically bonds to bone [5]. The biocompatibility, tolerance and biologically active property of HA makes it ideal material for bone substitutes [6]. Disadvantages – its long term outcome is not ideal as it has inconsistent cell reactions which limits its application in clinic [7]. A variant of HA called nano-HA has good biocompatibility, increases protein synthesis of PDL cells, improves alkaline phosphatase activity, induces cell differentiation, promotes periodontal tissue regeneration and forms new teeth attachments [8]. But the only disadvantage is limited bone regeneration (Li Shue, Biomaterials for periodontal regeneration: A review of ceramics and polymers, 2012) [3].

Tri Calcium Phosphate (TCP)

Advantages – It has been used for the past few years after thoroughly investigated as a bone substitute. The two crystallographic forms of TCP include; Alpha TCP, Beta TCP. Beta TCP shows the characteristics of good biocompatibility and osteo-conductivity [9]. When it comes to bone regeneration potential, β -TCP grafts have been shown to be like autogenous bone, FDBA, DFDBA and collagen sponge [10]. It can be used to repair periapical and marginal periodontal defects, as well as alveolar bony defects [10] however; some studies in the literature suggest that β -TCP could also be utilized for alveolar ridge augmentation in vertical and horizontal dimensions with variable results .Although it produces substantial clinical improvements in treating intra bony defects, it does not seem to regenerate cementum, PDL or bone (disadvantage) [11].

Calcium Polyphosphate (CPP)

Advantages – Calcium-Polyphosphate (CPP) is another good bone substitute as the mechanical properties are like trabecular bone. It has controlled degradability which is essential in tissue regeneration and El Sayegh et al. demonstrated that the degradation rate of CPP did not substantially affect the interactions of human gingival fibroblasts compared with titanium alloy substrates. CPP shows very good integration to host bone when implanted in vivo [12]. According to Nelson et al. CPP has a good bone regeneration potential after finding its ability to repair canine mandibular alveolar defects.

Brushite (Di Calcium Phosphate Dihydrate (DCPP))

Advantages – it has been shown that injectable brushite has the capability of regenerating bone. Potential applications of this material include vertical bone augmentation, buccal dehiscence defects. The only disadvantage associated with using brushite bone grafts is that after implantation, it will convert to HA which would limit its resorption rate. To overcome this advantage, a variant of Brushite called Monetite which will not convert to HA. By doing so, the resorption rate of Monetite is higher than Brushite [9].

Bioactive glass (BG)

Advantages – BG graft materials usually contain silicon dioxide, calcium oxide, sodium oxide, and phosphorus pentoxide. Studies have demonstrated that bioactive glass could induce bone formation as it enhances the expression of type I collagen, osteocalcin and alkaline phosphatase gene expression and osteocalcin protein [13]. Bioactive glass nanoparticles have been shown to induce cementoblasts to proliferate in an in vivo study [14]. BG grafts can be used as a supplement when the amount of the harvested autogenous grafts is not sufficient [15]. According to Mengel et al, BG produced a significant improvement in the parameters PD, CAL and distance from alveolar crest to defect base [16]. The disadvantage is that it has limited regenerative outcomes based on Nevins et al who conducted histological analysis [17].

Calcium Sulphate

Advantages – CS is used as a barrier material and it has greater compressive strength than cancellous bone and will resorb in 5- & 7 weeks [18]. It inhibits the epithelial and connective tissue in-growth to produce a predictable regenerative response [19]. CS easily adapts and adheres to the root surface, including root concavities [20]. In addition, CS is readily available, it can be easily sterilized, inexpensive (economic alternative to collagen), completely resorbable, and biocompatible, and in the presence of bone and periosteum, it becomes osteogenic [21]. No specific disadvantages have been found when this material was used.

Enamel Matrix Protein

Enamel Matrix proteins consist of three primary proteins which are similar to amelogenin, enamelin and sheathaline respectively with two enzymes and it is derived from porcine teeth. A wide range of in vitro and in vivo studies have demonstrated that EMD and

amelogenins stimulate growth of multiple mesenchymal cell types including fibroblasts, cementoblasts, osteoblasts, and stem cells [22]. In addition, it inhibits epithelial downgrowth. Although there are some controversies around using this EMP, some studies stated that it helps to repair bony defects in advanced intra bony defects. Recently, American Academy of Periodontology concluded that EMD is generally comparable with demineralized freeze-dried bone allograft and GTR in improving clinical parameters in the treatment of intra bony defects (Zeeshan Sheikh, Natural graft tissues and synthetic biomaterials for periodontal and alveolar bone reconstructive applications: a review, 2017) [9].

Platelet Rich Plasma and Platelet Rich fibrin

As these both (PRP & PRF) contains high platelets concentrate, these two play a role in augmentation of tissue healing, antimicrobial activity, modification of host defense mechanisms and immune reaction. The potential benefits of PRP is not consistent in the literature review because some authors reported significant improvements in tissue healing and bone formation using PRP [23, 24]. others failed to observe improvement [25, 26]. The technical and regenerative limitations of PRP restrict its applications. On the other hand, PRF has many advantages; completely autogenous, extended growth factor release for 7 days, simple and faster technique, in-expensive, no requirement of any additive constituent such as bovine thrombin, no biochemical handling involved no associated immune reactions and no associated infections [27]. The limitation of PRF is that a dried glass tube or glass coated plastic tube should be used. In addition, quantity and quality of PRF with aging, influence of systemic diseases such as thrombocytopenia, bleeding disorders etc, nutrition, blood profile, autoimmunity and genetic predisposition may influence the nature of PRF but not confirmed yet [27].

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