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Featured Review Article

Recent Advances in Orthodontic Retention Methods: A Review article

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ABSTRACT

Importance: Retention is an integral part of orthodontic treatment. Various biomedical agents, methods, and techniques have been introduced over the past 2 decades that could be useful in orthodontic retention. This review focuses on the underlying mechanisms and uses of these biomedical agents, lasers, vibrational therapies, and the most recent types of mechanical retainers. This review is also intended to serve as a resource for orthodontic researchers and clinicians. For researchers, it should facilitate further investigations into the clinical applications of the various agents and methods. For clinicians, it provides an up-to-date summary of new approaches that might be used in the future.

Observations: Several biomedical agents, including osteoprotegerin, bisphosphonates, bone morphogenic proteins, and relaxin, were reviewed. The applicability of low-level laser therapy (LLLT) and mechanical vibration also were evaluated, along with the modifications that have been introduced in conventional retention appliances.

Conclusion and Relevance: Among biomedical agents evaluated in this review, RANKL inhibitor agents, particularly denosumab, hold the greatest potential for future applications in orthodontic retention. In addition, LLLT has been associated with faster periodontal ligament maturation, especially if it is used with conventional retention methods, which might shorten the time required for retention after orthodontic treatment. Mechanical vibration has shown osteogenic effect on bone, even though it failed experimentally to inhibit relapse. Importantly, these new biomedical agents and techniques were mainly investigated experimentally, and further studies are required to confirm or refute their clinical applicability for orthodontic retention.

1. Introduction

The retention protocols and appliances used in orthodontics have witnessed a major changes in recent years with the incorporation of biological agents and adjunctive procedures, along with conventional approaches [1–4]. Review articles detailing conventional approaches, which compare and discuss the most commonly used retainers (e.g., fixed lingual retainers, removable thermoplastic retainers, and acrylic retainers) [5–7], along with a recent systematic review that comprehensively compared different commonly used retention protocols (fixed vs. removable, fixed vs. fixed, and removable vs. removable retainers) [8] exists in the literature. No previous publication has reviewed and synthesized current advances in orthodontic retention methods, which includes biological agents, low-level lasers, and newer retention protocols and designs. Thus, a review is deemed necessary to update the clinical community on the potential application of these newer materials and methods. Moreover, understanding these advances will help shape the future of orthodontic retention research by clarifying the potentials and limitations of each investigated agent, material, or technique.

Orthodontic biological research has developed greatly over the past 20 years. Multiple biological agents, such as osteoprotegerin (OPG), relaxin, bone morphogenic proteins (BMPs), and chemical agents, such as bisphosphonates (BPs) and simvastatin, have been investigated experimentally to determine whether they could be used to inhibit tooth movements and improve postorthodontic stability. The ability of low-level laser therapy (LLLT) and mechanical vibration devices to enhance postorthodontic stability also has been studied [9–11]. There also have been clinical studies evaluating composite resin retainers and introducing new retainer designs [12,13]. The aim of the present review was to evaluate current

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proposals in orthodontic retention, focusing on new materials and techniques that might serve as potential adjuncts or replacements for current retention protocols. The literature was systematically searched using MEDLINE (through PubMed) and ProQuest databases, covering both the published and unpublished literature that reported in English between 1996 and 2016. The review is presented in three sections: biomedical agents, laser and vibrational therapies, and mechanical retainers (Table 1).

2. Biomedical agents

The biological and pharmacological agents that have been investigated in orthodontics typically target factors that control bone metabolism. The ability of various hormones, cytokines, growth factors, and therapeutic agents to inhibit tooth movements has been well studied. This section discusses the biological mechanisms of action of various biomedical agents, focusing on their potential orthodontic applicability and suitability for further investigations.

2.1. Osteoprotegerin

OPG is an endogenous competitor protein that counteracts the resorptive action of RANKL (receptor activator of nuclear factor kappa-b ligand) by blocking it from binding to RANK. RANKL is a member of the tumor necrosis factor (TNF) superfamily actively involved in remodeling of bone and the periodontal ligament (PDL). It is considered essential for osteoclast differentiation, function, and survival [14]. Bone resorption is activated by binding of RANKL to RANK, another (TNF) family receptor that is present on osteoclast cells and their precursors [15]. Again, the role of OPG in the RANK-RANKL-OPG triad is to counter the action of RANKL. As a result, binding of OPG to RANKL produces an inhibitory effect on bone resorption, with profound reductions in osteoclast numbers (up to 95% reductions in osteoclasts have been reported in animal models during orthodontic tooth movement) [16,17]. The RANKL:OPG ratio is considered an important factor in bone metabolism, with increases and decreases of this ratio associated with bone resorption and formation, respectively.

Due to its antiresorptive effect, increased OPG levels result in a significant increase in bone mineral density and bone strength [18,19]. This shift of balance in bone metabolism toward bone formation is thought to result from the transient secondary effects of OPG on endogenous parathyroid hormone, which helps to maintain normal serum calcium levels and increase bone density and strength [20]. In medicine, OPG has been used to treat rheumatoid arthritis, osteoporosis, and other bone-related disorders [21–23]. The effectiveness, safety, and tolerability to OPG treatment has been studied in a randomized clinical trial on healthy postmenopausal women [24], which showed that it was well tolerated, and its effect was rapid, sustained, and reversible.

Table 1
Effects of biomedical agents, LLLT, and mechanical vibration on bone and PDL

Biomedical agent	Biological effect
Osteoprotegerin	Inhibits bone resorption and accelerates PDL maturation
Bisphosphonates	Inhibit bone resorption
Bone morphogenic proteins	Stimulate bone and PDL formation
Relaxin	Stimulates PDL turnover
Simvastatin	Stimulates bone formation
Strontium ranelate	Stimulates bone formation and inhibits bone resorption
LLLT	Stimulates both PDL and alveolar bone remodeling
Mechanical vibration	Inhibits bone resorption

LLLT, low-level laser therapy; PDL, periodontal ligament.

In orthodontics, OPG has been investigated to prevent relapse and enhance anchorage. Several experimental studies have shown that local or systemic injections of OPG inhibit orthodontic tooth movements and reduce relapse [16,17,25–30]. Keles et al. [16], who experimentally compared the effects of systemically injected OPG and BP on bone resorption and teeth movements, showed greater reductions in osteoclast numbers and lesser molar movements with OPG than BP. The same effects were also reported after localized OPG injections (5 mg/kg injected twice weekly for 3 weeks) [28]. These differences between the two agents were related to the fact that BP must be incorporated into the bone matrix to inhibit osteoclast activity [31], and OPG blocks RANK-RANKL binding, as well as differentiation of pre-osteoclasts to osteoclasts. Furthermore, BPs act only on active osteoclasts, whereas OPG inhibits osteoclast formation, function, and survival [32] (Fig. 1).

Additionally, OPG affects the amount of incisor retraction to molar anchorage loss. Different doses of OPG applied locally (0.5 mg/kg or 5 mg/kg), have been experimentally assessed [25]. The ratios of incisor retraction to molar anchorage loss were 2.3 to 1.0 mm, 2.0 to 1.0 mm, and 5.2 to 1.0 mm in the control, low-dose, and high-dose groups, respectively. Schneider et al. [27] also reported greater inhibition of molar than incisor movement with a higher dose of OPG. They showed no detrimental effects of OPG on PDL cells.

In addition, OPG inhibits bone loss in both lipopolysaccharide and ligature-induced periodontitis [33,34]. There was a faster PDL maturation with OPG [26], without any epithelial tissue abnormalities [28]. Rapid maturation of PDL and inhibition of bone resorption, the properties exhibited by OPG, are considered desirable after orthodontic treatment. Moreover, local injection of OPG appears to induce endogenous OPG expression in periodontal tissues, with no signs of severe inflammation [17,29,35]. Furthermore, OPG has been reported to inhibit external root resorption due to inhibitory effects on cementoclasts. The external root resorption repair ratio was significantly increased in the OPG group (75.7%), compared with 37.1% in the control group [35]. At the cellular level, immunohistochemical analyses of osteolytic markers, such as RANK, Runt-related transcription factor-2 (RUNX-2), Vimentin, acid-sensing ion channel 2 (ASIC2), transient receptor potential cation channel subfamily V member 4 (TRPV4), matrix metalloproteinases (MMPs), and tissue inhibitor of metalloproteinase, indicating decrease in bone remodeling, with no changes in type I collagen expression, the major

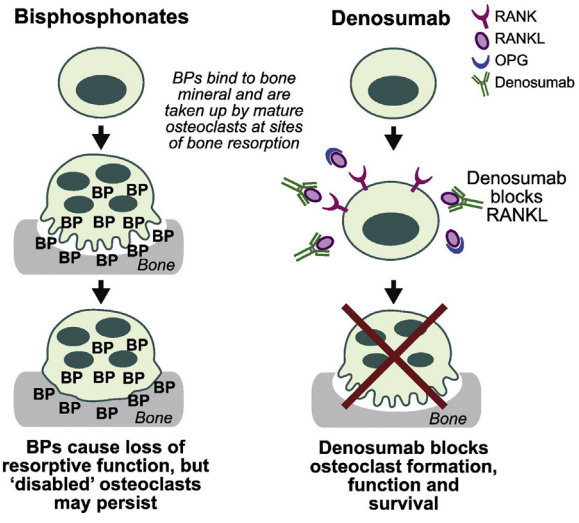

Fig. 1. BPs and denosumab mechanism of action on osteoclasts. Adapted with permission from Baron R, Ferrari S, Russell RG. Denosumab and bisphosphonates: different mechanisms of action and effects. Bone 2011;48:677–92. © 2010 by Elsevier.