

VARIOUS BIOLOGICAL APPROACHES TO ACCELERATE TOOTH MOVEMENT DURING ORTHODONTIC TREATMENT: A REVIEW

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ABSTRACT

Duration of the orthodontic treatment has always been an issue in the orthodontic fraternity. Nowadays, there is an increased tendency for researches to focus on accelerating methods for tooth movement due to the huge demand for adults for a shorter orthodontic treatment time. Unfortunately, long orthodontic treatment time poses several disadvantages like higher predisposition to caries, gingival recession, and root resorption. This increases the demand to find the best method to increase tooth movement with the least possible disadvantages. The purpose of this study is to view the successful approaches in tooth movement and to highlight the newest technique in tooth movement. A total of 50 articles were reviewed in tooth movement and related discipline. In various researches done, cytokines PTH, Vit D, have shown good results. Due to the advantage and disadvantage of each approach further investigation should be done to determine the best method to accelerate tooth movement.

KEYWORDS: Biological approaches, tooth movement, orthodontic movement

INTRODUCTION

Orthodontics has been developing greatly in achieving the desired results both clinically and technically. Continuous modification of wires and brackets has also increased the efficiency of orthodontic treatment. However biomechanical systems have reached their limits and hence there is a need to develop new methods that may accelerate the teeth movement. Number of

attempts have been made to create different approaches in order to achieve quicker results but still there are a lot of unanswered questions towards most of the technique. Before going into details of these attempts, we need to understand the basics of orthodontic tooth movements and the factors that initiate inhibition and delayed tooth movement. Orthodontic tooth movement occurs in the presence of mechanical stimuli resulting remodeling of alveolar bone and periodontal ligament. Bone remodeling is a process in which bone resorption take place in pressure site and bone formation takes place in the tension site.^[1] Orthodontic tooth movement is controlled by amount of applied force and biological responses from the periodontal ligament.^[2] The force applied to the teeth alters the blood flow leading to the secretion of different inflammatory mediators such as Cytokines, Growth factors etc. As a result of these secretions, remodeling of the bone occurs.^[3,4] There are three phases of tooth movement: the initial phase, which is characterized by rapid movement after the application of force; followed by a lag period, where little or no movement, and the last phase, where gradual or sudden increase of movement occurs.^[5] The early phase of tooth movement involves acute inflammatory responses characterized by leucocytes migrating out of blood capillaries and producing cytokines, which stimulates the excretion of prostaglandins and growth factors.^[6] The acute phase is followed by the chronic phase that involves the proliferation of fibroblast, endothelial cells, osteoblasts, and alveolar bone marrow cells remodeling process.^[4]

Table 1 Biological approaches to enhance tooth movement

Authors	Biological molecules tested	Animal or humans	Duration	Acceleration
Saito <i>et al.</i> ^[9]	PGs and IL-1	Cats	Weeks	Yes
Yamasaki <i>et al.</i> ^[10]	PGs	Rats	Weeks	Yes
Yamasaki <i>et al.</i> ^[11]	PGs	Monkeys	Weeks	Yes
Leiker <i>et al.</i> ^[7]	PGs	Rats	Weeks	Yes
Yamasaki <i>et al.</i> ^[12]	PGs	Human	Months	Yes
Seifi <i>et al.</i> ^[13]	PGs + Ca	Rats	Weeks	Yes and stabilize root resorption
Seifi <i>et al.</i> ^[13]	PGs – Ca	Rats	Weeks	Yes
Kanzaki <i>et al.</i> ^[14]	RANKL/RANK	Animals	Weeks	Yes
Nishijima <i>et al.</i> ^[15]	RANKL/RANK/OPG and root resorption	Human	Months	Relation with root resorption
Collins <i>et al.</i> ^[16]	Vitamin D	Cats	Weeks	Yes
Kale <i>et al.</i> ^[17]	Vitamin D and PGs	Rats	Weeks	Yes
Soma <i>et al.</i> ^[18]	PTH	Rats	Weeks	Yes
Soma <i>et al.</i> ^[19]	PTH	Rats	Weeks	Yes
Liu Zi <i>et al.</i> ^[20]	Relaxin	Rats	Weeks	Yes
Mcgorray <i>et al.</i> ^[21]	Relaxin	Human	Weeks	No

BIOLOGICAL APPROACH

Experiments have been done using these molecules to enhance tooth movement both in animals and humans. Example of these molecules are Prostaglandins E, Cytokines^[7-9] etc.

EFFECT OF CYTOKINES ON TOOTH MOVEMENT

High concentration of cytokines such as interleukins IL-1, IL-2, IL-3 IL-6, IL-8, and tumor necrosis factor alpha (TNF) were found to play a major role in bone remodeling; moreover, interleukin-1 (IL-1) stimulates osteoclast function through its receptor on osteoclasts.^[3] It was also found that mechanical stress due to orthodontic treatment increased the production of prostaglandin PGE and IL-1 beta in the periodontal ligaments. These experiments were done on cats where one canine was tipped distally by 80 g of force from hours to days, then immunohistochemistry and microphotometry experiments were done to measure the intensity of PGE and IL-1 beta which was found to be highest on the tension.^[9] Other cytokines which are also involved in the acceleration of tooth movement are RANKL, which is a membrane-bound protein on the osteoblasts that bind to the RANK on the osteoclasts and causes osteoclastogenesis.^[22-24] The process of bone

remodeling is a balance between (RANKL-RANK) system and OPG compound.^[25,26] In another study it was found that juvenile teeth move faster than adults, which is due to the lower amount of RANKL / OPG ratio in the gingival crevicular fluid (GCF) in adult patients measured by the enzyme-linked immunosorbent assay method. Also a correlation was found among RANK, OPG, and root resorption during orthodontic teeth movement, and patients with root resorption produced a large amount of RANKL in the compressed site.^[15,27]

PTH EFFECT ON TOOTH MOVEMENT

The effect of PTH is very effective on accelerating the orthodontic tooth movement as it is evident in the study where continuous infusion of PTH (1-10 micrograms/100 grams of body weight/day) in dorsocervical region moved molars 2-3 folds faster). Some studies have confirmed that locally injected PTH induces local bone resorption and it is more advantageous to give PTH locally rather than systemically²⁸. Slow release application that keeps local concentration of PTH for a long time was also found very efficient.^[19]

EFFECT OF VIT D3 ON TOOTH MOVEMENT

Vitamin D3 has also attracted the attention of

some scientist to its role in the acceleration of tooth movement; 1,25 dihydroxycholecalciferol is a hormonal form of vitamin D and plays an important role in calcium homeostasis with calcitonin and parathyroid hormone (PTH). Another set of investigators,^[16] has made an experiment where they have injected vitamin D metabolite on the PDL of cats for several weeks; it was found that vitamin D had accelerated tooth movement at 60% more than the control group due to the increasement of osteoclasts on the pressure site as detected histologically. A comparison between local injection of vitamin D and PGEs on two different groups of rats was also investigated. It was found that there is no significant difference in acceleration between the two groups. However, the number of osteoblasts on the pressure side which was injected by vitamin D was greater than on the PGE2 side. This indicates that vitamin D may be more effective in bone turnover.^[17]

EFFECT OF RELAXIN ON TOOTH MOVEMENT

Relaxin effect has also been investigated. Relaxin is a hormone that helps during childbirth by widening of the pubic ligaments in females and is suggested to be present in cranial suture and PDL.^[29] The role of relaxin is known in the remodeling of soft tissue rather than remodeling of bone. It has been shown that it increases collagen in the tension site and decreases it in compression site during orthodontic movement.^[30,31] Also, the administration of human relaxin may accelerate the early stages of orthodontic tooth movement in rat experiments.^[20] However, another study showed that human relaxin does not accelerate orthodontic tooth movement in rats, but can reduce the level of PDL organization and mechanical strength of PDL and increase tooth mobility.^[21] In these experiments in vitro studies were also performed to test the PDL mechanical strength and tooth mobility using tissue from additional 20 rats that had previously received the same relaxin treatment for several days.^[21] The remodeling of PDL by relaxin might reduce the rate of relapse after orthodontic treatment as suggested by others.^[32] Recently, randomized clinical trials on humans were done by weekly injections of 50 µg of relaxin or placebo control for 8 weeks. Tooth movement was measured

weekly on polyvinyl siloxane impressions which were scanned digitally. There was no significant difference between the relaxin and the placebo control group regarding the acceleration and relapse.^[21] However, the mechanism of how relaxin accelerates tooth movement is not yet fully understood.

EFFECT OF PROSTAGLANDIN ON TOOTH MOVEMENT

Prostaglandins (PGs) are inflammatory mediator and a paracrine hormone that acts on nearby cells; it stimulates bone resorption by increasing directly the number of osteoclasts. In vivo and in vitro experiments were conducted to show clearly the relation between PGs, applied forces, and the acceleration of tooth movement. Yamasaki^[10,11] was among the first to investigate the effect of local administration of prostaglandin on rats and monkeys. In addition, experiments^[7] done in have shown that injections of exogenous PGE2 over an extended period of time caused acceleration of tooth movements in rats. Furthermore, chemically produced PGE2 has been studied in human trials with split-mouth experiments in the first premolar extraction cases. In these experiments the rate of distal retraction of canines was 1.6-fold faster than the control side.^[12]

CONCLUSION

In general all the approaches have their own flaws and that is the reason behind their limited use clinically. These approaches have the potential to be the next frontier for orthodontics and resources but still further investigations and studies are required to decrease their unwanted effects and increase their efficiency and acceptability in the clinical practise.

CONFLICT OF INTEREST & SOURCE OF FUNDING

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