

DIFFERENT METHODS TO ACCELERATE ORTHODONTIC TOOTH MOVEMENT

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Abstract

Today, orthodontic treatment times have been shortened. We do have methods that can enhance orthodontic tooth movement safely with less adverse effects. However shedding more light on how to use them more efficiently and effectively in orthodontics is needed, further studies should encourage the search for new and exciting, and hopefully, less invasive procedures. To evaluate various minimally invasive procedures for the enhancement of orthodontic tooth movement. This review encapsulates the current knowledge on the molecular mechanisms underlying accelerated orthodontic tooth movement, and the clinical and experimental methods that accelerate orthodontic tooth movement.

Keywords: Orthodontic tooth movement, Corticotomy, Micro-osteoperforations, Lasers, Piezosurgery, Vibration.

Introduction

The time concern in orthodontic treatment is the primary concern of most patients. Unfortunately, long orthodontic treatment time poses several effects like higher predisposition to dental caries, gingival recession and root resorption. Therefore, increasing the demand to find the best method to increase rate of tooth movement with least possible effects. Adjacent investing tissues, certain mechanical, chemical, and cellular events take place within these tissues; Orthodontic treatment is based on the premise that when force is delivered to a tooth and thereby transmitted which allow for structural alterations and contribute to the movement of that tooth. All these methods were based on principle that when the bone is irritated surgically, an inflammation cascade is initiated which causes increased osteoclastogenesis, which causes faster tooth movement (Regional Acceleratory Phenomenon or Periodontally Accelerated Osteogenic Orthodontics).¹ Many methods are available to accelerate tooth movement, like surgical methods (corticotomy, piezosurgery etc), mechanical/ physical stimulation methods (vibration, lasers), drugs, magnets etc. These methods successfully proven to reduce treatment times by up to 70%. Plenty of methods been tried, some like lasers and vibration seem to show most likely. Some methods proved by inducing osteo-clastogenesis and Rank/Rankl pathways and induction of signalling molecules such as MAPK (Mitogen Activated Protein Kinase), c-fos, and nitric oxide.^{2,3} These techniques shown to reduce relapse, pain and root resorption caused due to orthodontic forces. Hence, this article aims to review the latest methods to accelerate orthodontic tooth movement.

Techniques to accelerate OTM

The following Techniques to accelerate orthodontic tooth movement

1. Drugs.
2. Surgical Methods.
3. Physical/ Mechanical stimulation methods.

1. Drugs

Drugs present like vitamin D, prostaglandin, interleukins, parathyroid hormone etc. The other unwanted adverse effects take place as a role. For example, vitamin D when

injected in the PDL increases the levels of LDH and CPK enzymes; prostaglandin causes a generalized increase in the inflammatory state and causes root resorption. Hence, in the present day, no drug exists or plays safely to accelerate orthodontic tooth movement.

Prostaglandins: Orthodontic tooth movement associated with inflammatory reactions induced by mechanical stimuli form the biological basis in remodeling activities. Yamasaki et al. in a series of experiments with rat tooth model demonstrated that injection of PGs increased osteoclasts numbers.⁴ The first human study was done by Yamasaki et al. and 2nd by Patil et al. in 1999. Both studies clearly stated that there is almost twice faster orthodontic tooth movement can be accomplished by local injection of prostaglandins.^{5,6}

Thereby, Researchers to inject PGs at the site where orthodontic tooth movement needed, to intensify the bone remodeling process, and thereby augment the rate of orthodontic tooth movement.

Vitamin D: Vitamin D most active metabolite which is (1,25-dihydroxyvitamin D₃) (1,25(OH)₂D₃) with parathyroid hormone and calcitonin, regulates the amount of calcium and phosphorus in humans. It effects on bone resorption and formation and is balanced in modulating bone turnover during orthodontic tooth movement therefore Vitamin D is more effective.

Parathormone: parathyroid glands produced to regulate serum calcium concentration. PTH mostly affects on osteoblasts cellular metabolic activity, gene transcriptional activity, and multiple protease secretions, osteoclasts occur through the production of Rankl, a protein that plays a critical role in osteoclast formation and its activity. Uninterrupted raise of PTH leads to bone loss; intermittent short elevations of the hormone level can be anabolic for bone. Increase in bone mass, density, and strength shown in many experimental and clinical data. But, all of these drugs have some or the other adverse effect.⁷

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prostaglandin causes an increase in the inflammatory state and root resorption. Hence, as of today, no drug exists that can safely accelerate orthodontic tooth movement.

2. Surgical Methods

Corticotomy: This involves elevation of full thickness mucoperiosteal flaps, buccally and/or lingually, followed by placing the cuts either by using micromotor under irrigation, or piezosurgical instruments. Placement of graft material procedure is followed, augmentation of bone thickness is done where it is required. In 2001, Wilcko et al. delineated that a surface-computed tomographic evaluation of corticotomized patients showed an ephemeral localized demineralization-remineralization processes harmonious with the accelerated wound healing pattern of the regional acceleratory phenomenon.^{7,8} Park et al. in 2006 and Kim et al. in 2009, a minimal invasive surgically introduced the corticision technique, injure the bone without flap elevation.⁹ Disadvantages are high morbidity associated Chances of damage to adjacent vital structures, Post-operative pain, chances of infection, avascular necrosis, swelling and acceptance of patient is low.¹⁰

Wilckodontics: Is also termed as Accelerated Osteogenic Orthodontics, involves a periodontal procedure combined with orthodontics to reach end treatment results 3 to 4 times rapid than conventional orthodontic treatment procedures. In the 1950s, periodontists started using corticotomy procedures to increase the rate of tooth movement. Alveolar corticotomies (ACS) are defined as a surgical intervention limited to the cortical portion of the alveolar bone. The incision must pierce and go through the cortical layer, and at the same time, penetrate into the bone marrow minimally only. In the 1990s, Drs. Wilcko, concluded that a noticeable reduction in mineralization of the Alveolar bone was the reason for the accelerated tooth movement following corticotomy procedures. In 1995, Drs. Wilcko patented AOO (Accelerated Osteogenic Orthodontics) technique. In severe bimaxillary protrusion, closure of complex skeletal open bites, facilitated molar intrusion with removable appliances, intrusion and molar uprighting combining ACS and mini implants, and optimization of treatment of patients with cleft lip and palate, where reports has shown a successful use of AOO (Accelerated Osteogenic Orthodontics) in enhanced correction.⁸

Piezocision: To decrease the morbidity associated with the traditional corticotomy, Dibart et al. in 2009 introduced a flapless method of corticotomy, using piezosurgery.¹⁰ In this technique, under local anaesthesia surgery was performed 1 week after placement of orthodontic appliance. Vertical incisions were given in the attached gingiva, gingivally on buccal side below the interdental papilla as far as possible using a No.15 scalpel. The incisions were deep enough to pass through the periosteum and contact the cortical bone. After that

using ultrasonic instrumentation (they used a BS1 insert Piezotome), perform the corticotomy cuts upto a depth of 3 mm through the previously made incisions. Where the areas requiring bone augmentation, tunnelling is performed to create sufficient space for a graft material. where the graft material needs to be stabilized suture must be placed. Then, Patient is advised for an antibiotic and mouthwash regimen. As incisions and corticotomies are “blindly” done there is a risk of root damage this is the disadvantage in piezocision.

Microosteoperforation: MOP is the only micro-invasive choice capable to speed up orthodontics. MOP gives expected orthodontic treatment results, enhances finishing with braces and decreases or eliminates refinements with clear aligner therapy. MOP can be finished on chair side in very less time, and does not need any advanced training procedures; hence, any trained clinician can perform it. In addition there is zero recovery time, and the patients are able to immediately return to their normal daily routine. This technique is indicated for majority of patients receiving orthodontic treatment and can be used in conjunction with other treatment modalities including but not restricted to, TADs, Invisalign (Align Technology), SureSmile (OraMetrix), and conventional braces.¹¹ Dentoalveolar Distraction-Distractor osteogenesis is a procedure in which growth of the new bone by mechanical stretching of the pre-existing bone tissue. The technique of distraction osteogenesis involves mechanical stretching of the reparative bone tissue by a distraction device through an osteotomy or corticotomy site. With this technique, new bone is generated in the gap of osteotomy or corticotomy at the approximate rate of 1 mm per day. This has been used for lengthening mandibles than moving individual teeth. Liou et al. (1998) found that when distractor was used in between premolars, able to achieve rates of tooth movement of up to 1.2mm/week. Iseri et al. (2005) in a study said that they achieved tooth movement of 0.8mm per day by moving a canine and its associated block of bone into a premolar extraction space through a distractor appliance. There were no adverse effects such as periodontal problems, ankyloses and root resorption.^{12,13}

3. Physical/Mechanical Stimulation

Surgical methods are invasive to some extent, associated with some complications. Hence, non-invasive methods include lasers, vibration, direct electric current, etc.

Low-Level Laser Therapy (LLLT): LLLT are stimulatory effects can accelerate bone regeneration in a mid palatal suture during rapid palatal expansion and stimulate synthesis of collagen, which is a major matrix protein in bone. Studies and observation in rats found increase in rate of tooth movement, laser irradiation causes bone regeneration at bone fracture areas and extraction sites, LLLT seems to be a good option for its stimulatory effects in orthodontic tooth movement as it increases alveolar bone remodelling without hurting the

tooth and periodontium. In 2004, Cruz et al. was the first to start a human study on the effects of low-intensity laser therapy in orthodontic tooth movement, showed that the irradiated canines were retracted at a greater rate than the control canines by 34% over 60 days.¹⁴ In 2015, Kazem Dalaie et al. concluded laser enhanced orthodontic tooth movement in the upper jaw, but they failed to provide solid evidence to support the efficacy of laser for expediting tooth movement or reducing the associated pain.¹⁵

Vibration: Nishimura et al. in 2008, used Ni-Ti expansion spring on Wistar rats and applied a vibration of 60 Hz, 1 m/s². The rats that received vibration showed increased tooth movement. In the sectioned samples of vibration received rats showed increased RANKL expression in the fibroblasts and osteoclasts of the periodontal ligament of rats.¹⁶ More recently, a product *Acceledent* has arrived, it consists of an activator, which is the active part of the appliance. Activator delivers the vibration impulses with a USB interface by which it can be connected to a computer to review the patient usage of the appliance, a mouthpiece that contacts the teeth. Various case studies using this device have shown the treatment times to be reduced by up to 30-40%.¹⁷

Acceledent System: It is a simple, removable and non-invasive appliance, works through the application of electromechanical vibrations. 20 minutes of daily use enhances the orthodontic force applied by braces or aligners to accelerate the rate of orthodontic tooth movement. It is designed to deliver gentle micro vibrations in a way that is comfortable and easy to use. Orthodontic treatment time shortened and its associated benefits to correct malocclusion and a great smile.

Patient Benefits:

1. Shortened treatment time without compromised aesthetics
2. Low risk of caries or gum disease with less treatment time
3. Clinical trial demonstrates excellent root resorption safety profile

Conclusion

Today, orthodontic treatment times have been shortened. We do have methods that can enhance orthodontic tooth movement safely with less adverse effects. However shedding more light on how to use them more efficiently and effectively in orthodontics is needed, further studies should encourage the search for new and exciting, and hopefully, less invasive procedures. Most potential methods of accelerating orthodontic tooth movement are in the early stages of research; testing the potential benefits as well as their safety and side effects. The efficacy of these experimental procedures should be substantiated, and then they may become a part of routine orthodontic treatment procedures.

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