REVIEW ARTICLE

Speedy Orthodontics: A Comprehensive Review

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ABSTRACT

The time span of orthodontic treatment is the principal concern of many orthodontic patients. Unfortunately, long orthodontic treatment time poses several disadvantages like a higher predisposition to dental caries, gingival recession and root resorption. Accelerating orthodontic tooth movement can notably reduce treatment duration and risks of side effects. The conventional orthodontic treatment process is slow and orthodontic treatment times can range anywhere in between 12-48 months. Plenty of methods are available to accelerate tooth movement, such as surgical methods (corticotomy, piezosurgery, etc.), mechanical/physical stimulation methods (vibration, lasers), drugs, etc. These methods have successfully proven to reduce treatment times by up to 70%.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: Orthodontics, Treatment, Accelerated Tooth movement.

INTRODUCTION

Patient's primary concern before starting orthodontic treatment is how long treatment will proceed. In the past years, new devices and techniques have made the orthodontic process more systematic and effective, but not reduced the orthodontic treatment time. Many revolutionary innovations have been introduced to improve bracket design and treatment protocols; however, the only effective technique to decrease the treatment time involves extensive surgery. All these methods were based on the principle that when the bone is irritated surgically, an inflammtion cascade is initiated which causes increased osteoclastogenesis, which causes faster tooth movement (Regional Acceleratory Phenomenon or Periodontally Accelerated Osteogenic Orthodontics).[1] These methods were invasive and not well accepted by the patients. Hence, newer surgical methods have arrived with the help of piezosurgery, fiberotomy, micro-osteoperforations, etc. which achieve the same results as achieved by conventional corticotomy, but with reduced invasiveness and morbidity.

Mechanical or physical stimulation of the periodontal ligament has shown to increase the speed of bone remodelling. Plenty of methods have been tried for this purpose, out of them lasers and vibration seem to show most likely. Those methods proved to act 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 have shown to reduce relapse, pain and root resorption caused due to orthodontic forces.

TECHNIQUES IN SPEEDY ORTHODONTICS

Techniques to accelerate orthodontic tooth movement can be widely studied under the following categories:

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

1. DRUGS:

A. Prostaglandins- Remodeling activities associated with inflammatory reactions induced by mechanical stimuli form the biological basis for orthodontic tooth movement. This led 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. 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 ANAND K PATIL et al. in 1999. Both studies depict clearly that almost twice faster orthodontic tooth

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movement can be accomplished by local injection of prostaglandins.[5,6]

B. **Vitamin D-** Vitamin D and especially its most active metabolite which is 1,25-dihydroxyvitamin D3 ($1,25(OH)_2D_3$) together with parathyroid hormone and calcitonin, regulates the amount of calcium and phosphorus in humans. Vitamin D is more effective in modulating bone turnover during orthodontic tooth movement because its effects on bone resorption and formation are balanced.

C. **Parathormone-** Produced by the parathyroid glands to regulate serum calcium concentration. PTH affects osteoblasts cellular metabolic activity, gene transcriptional activity, and multiple protease secretions. PTH effects on 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. Many experimental and clinical data show that such daily applications of short duration led to increasing bone mass, density, and strength.

But, all of these drugs have some or the other adverse effect. For example, vitamin D when injected in the PDL increases the levels of LDH and CPK enzymes; 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.[7]

2. SURGICAL METHODS:

A. **Corticotomy-** The standard corticotomy procedure involves elevation of full thickness mucoperiosteal flaps, buccally and/or lingually, followed by placing the corticotomy cuts by using either micromotor under irrigation, or piezosurgical instruments. This procedure is followed by the placement of graft material, where it is required, to augment the bone thickness. In 2001, Wilcko et al. delineated that a surface-computed tomographic evaluation of corticotomized patients clearly showed a 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 introduced the corticision technique, as a minimal invasive alternative to surgically injure the bone without flap elevation.[9]

Disadvantages are high morbidity associated with the Invasive procedure, Chances of damage to adjacent vital structures, Post-operative pain, chances of infection, avascular necrosis, swelling and Low acceptance by the patient.[10]

B. **Wilckodontics-** Also known 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 were 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, the 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 the AOO (Accelerated Osteogenic Orthodontics) technique. Reports can be found that describe the successful use of AOO in enhanced correction of 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.[8]

C. **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 they described that the surgery was performed 1 week after placement of orthodontic appliance, under local anaesthesia. 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 so as 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. Suturing is required for the areas where the graft material needs to be stabilized. Patient is placed on an antibiotic and mouthwash regimen.

Disadvantage is risk of root damage, as incisions and corticotomies are “blindly” done.

D. **Micro-osteoperforation-** Micro-osteoperforation (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 chairside 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- Distraction 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.[12] 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.[13]

3. PHYSICAL/MECHANICAL STIMULATION:

Surgical methods are invasive to some extent and have their own associated complications. Hence, non-invasive methods were invented. These modalities include lasers, vibration, direct electric current, etc.

A. **Low-Level Laser Therapy-** Low-level laser therapy (LLLT) found that its 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. Some studies found that laser irradiation causes bone regeneration at bone fracture areas and extraction sites and increase the rate of tooth movement in a rat. From these observations in rats, LLLT seems to be a good option for its stimulatory effects of speeding up orthodontic tooth movement as it increases alveolar bone remodelling without hurting the tooth and periodontium.

In 2004, Cruz et al. were the first to start a human study on the effects of low-intensity laser therapy in orthodontic tooth movement. They 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 that 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]

B. **Vibration-** Nishimura et al. in 2008, used a Ni-Ti expansion spring on Wistar rats and applied a vibration of 60 Hz, 1 m/s^2. 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 by name Acceledent has arrived, which makes use of this technique. Acceledent 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]

C. **Acceledent System-** It is a simple, removable and non-invasive appliance. Complements the orthodontic force applied by braces and works through the application of electromechanical vibrations. Just 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 this daily therapy - in the form of gentle micro vibrations - in a way that is comfortable and easy to use. The benefit is shortened orthodontic treatment time and all of the benefits associated with the fast track to correct malocclusion and a great smile.

Patient Benefits:-

- Reduced treatment time without compromised aesthetics
- Less prone to caries or gum disease with shortened treatment
- Clinical trial demonstrates excellent root resorption safety profile

CONCLUSION

Orthodontic patients have been asking for shorter orthodontic treatment times, and today, 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, then they may become a part of routine orthodontic treatment procedures.

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