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RESEARCH ARTICLE

EXPEDITE THE ORTHODONTIC TREATMENT: A REVIEW

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ABSTRACT

Patient's primary concern before starting orthodontic treatment is how long treatment will proceed. 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. 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.

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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 (Frost, 1983). Lengthy orthodontic treatment prompts many patients, especially adults, to either avoid treatment or to seek shorter alternative solutions with compromised results. Therefore, the treatment modalities that decrease treatment time without compromising the treatment outcome is an active area of research in orthodontics today. Clinicians are constantly striving towards developing potential strategies to enhance the rate of orthodontic tooth movement. Recently, numerous methods have been proposed to enhance the rate of orthodontic tooth movement so that faster and better treatment options can be provided to the patients.

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These methods 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 (Nimeri, 2013; Nishimura *et al.*, 2008). Thus the aim of this article is to enumerate and discuss different methods to accelerate orthodontic tooth movement.

Methods to accelerate orthodontic tooth movement are discussed under the following categories:

- Surgical Methods.
- Device assisted therapy or Mechanical stimulation methods.
- Drugs

Techniques in speedy orthodontics

Surgical Methods: Several surgical approaches that have been tried in order to accelerate tooth movement are Corticotomy and Piezocision technique.

Corticotomy: It was first tried in orthodontics by Kole[4]. 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. Conventional corticotomy is one of the surgical procedures that is commonly used, in which only the cortical bone is cut and perforated but not the medullary bone. This will reduce the resistance of the cortical bone and accelerate tooth movement. It was suggested that bony blocks were created as a result of the corticotomy, hence causing faster tooth movement.

Advantages

- Corticotomy procedure causes minimal changes in the periodontal attachment apparatus[6].
- It has been proven successfully by many authors to accelerate tooth movement (Shenava, ?; Fischer, 2007).
- Bone can be augmented; thereby preventing periodontal defects (Bilal, 2015).

Disadvantages

- Invasive procedure leading to high morbidity.
- Chances of damage to adjacent vital structures.
- Postoperative pain and swelling.
- Chances of infection or avascular necrosis.
- Low acceptance by the patient (Shenava, ?; Dibart, 2009).

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 (Wilcko, 2001).

Piezocision: Dibart *et al.* in 2009 introduced a flapless method of corticotomy, using piezosurgery (Dibart, 2009). 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. Disadvantage is risk of root damage, as incisions and corticotomies are “blindly” done.

Micro-Osteoperforations (MOP): Micro-osteoperforation (MOP) is the only micro-invasive choice capable to speed up orthodontics. The use of this device in animals has shown that performing micro-osteoperforations (MOPs) on alveolar bone during orthodontic tooth movement can stimulate the expression of inflammatory markers which leads to increase in osteoclast activity and rate of tooth movement. Mani Alikhani *et al* (2013) performed a single center single blinded study to investigate this procedure on humans. He found that MOPs significantly increased the expression of cytokines and chemokines which are known to recruit osteoclast precursors and stimulate osteoclast differentiation. MOPs increased the rate of canine retraction 2.3-fold compared to the control group.

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, it wable to achieve rates of tooth movement of up to 1.2mm/week (Liou, 1998). 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 (Iseri *et al*., 2005).

Device assisted therapy or Mechanical stimulation methods: Surgical methods are invasive to some extent and have their own associated complications. Hence, non-invasive methods were invented. They include direct electric current, pulsed electromagnetic field, static magnetic field, resonance vibration, and low level laser. The thought of using physical approaches came from the concept that applying orthodontic force causes bone bending which develops bioelectrical potential. The cyclic impulses generated by these devices would generate the same bioelectric field. The concave site will be negatively charged attracting osteoblasts and the convex site will be positively charged attracting osteoclasts (Zengo, 1974).

Direct Electric Current

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

Vibration: Nishimura *et al*. in 2008 used a 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 (Nishimura *et al*., 2008). 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% (Acceledent, ?).

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. 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 (Doshi-Mehta, 2012). 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 (Kazem Dalaie, 2015). Thus, 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.

DRUGS

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 (Yamasaki, 1980). 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 movement can be accomplished by local injection of prostaglandins (Yamasaki, 1984; Anand k patil, 2006).

Vitamin D: Vitamin D and especially its most active metabolite which is 1, 25-dihydroxyvitamin D3 (1,25(OH)2D3) 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.

Parathormone: Produced by the parathyroid glands to regulate serum calcium concentration. PTH affects osteoblasts cellular metabolic activity, gene transcription-nal 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.

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. Tooth acceleration phenomenon is still a relatively new horizon and researchers have yet to seek a single most ideal and prudent technique for the patient. The surgical techniques have most of the human trials and also show very favorable and long term effects adding to the stability and retention of the orthodontic therapy. However the invasiveness and cost of these might make it little less viable option for the patients. Microsteoperforation, Piezoincision on the other hand are the least discomforting among all the surgical procedures and this will make them more commonly used procedures in future. Yet at the same time any of these techniques once adapted depending upon clinician's choice and patient's preference; can prove to be immensely beneficial in reducing orthodontic treatment time.

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