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Accelerated Orthodontics

Anand K. Patil and Amrit Singh Maan

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Abstract

Clinical orthodontics is ever dynamic branch of Dentistry. Traditionally orthodontics was always considered as aesthetic treatment of face & also needed for proper oral oral function. This treatment may take up 2–3 years of total duration. The chapter describes changing trends in this aspect wherein we speed up the treatment by various methods thus reducing the overall time duration. These modalities include alteration in bio mechanics, pharmacological, chemical & by biological means. It is also cautioned here that the clinician has to take up these changing trends based on sound clinical knowledge & evidence based applicability.

Keywords: biology of tooth movement, acceleration of tooth movement, prostaglandins, regional acceleration phenomena, corticotomy

1. Accelerated orthodontics

Orthodontic treatment in the present day does not just require to meet the demands of creating the functional harmony in occlusion and improving the aesthetic outlook of but is should also be completed in the most efficient duration that is accepted by the patient and the orthodontist. We live in a fast-paced world where the treatment duration has clearly made the field of orthodontic treatment to revolve around it. Accelerated orthodontic tooth movement is not something that has recently emerged; it has been studied and tried out for many years. In an attempt of producing faster tooth movement during orthodontic treatment, there are numerous methods of accelerating tooth movements that have been introduced over the years which range from surgical means to the use of laser therapy. Now let us look at each method explained in this chapter.

2. Methods of accelerated tooth movements

We can categorise the methods of accelerated tooth movement into the following categories:

- A. Pharmacological methods
- B. Surgical methods
- C. Physical methods

2.1. Pharmacological methods

Orthodontic forces cause a fluid movement in the periodontal ligament space and distortion of the matrix and cells. There is release of molecules which initiate bone remodelling for tooth movement [1]. There are a number of researches on pharmacological agents that act as biomodulators for increased orthodontic tooth movement. These are examples of such biomodulators:

- Prostaglandin E_2 and Prostaglandin E_1
- Misoprostol
- 1,25-Dihydroxycholecalciferol
- Parathyroid hormones
- Intravenous immunoglobulins

Prostaglandin E_2 (PGE_2) is an arachidonic acid metabolite is an often-tested substance to increase orthodontic tooth movement [2]. Animal studies have shown PGE_2 to increase tooth movement and facilitate bone resorption [3–6]. Camacho and Velásquez Cujar conducted a study that showed that it required repeated injections due to its short half-life [7]. Particular synthases that are required for the synthesis of PGE_2 could be targeted to control the production of the prostaglandins [8].

Another prostaglandin that has been reported to speed up orthodontic tooth movement is Prostaglandin E_1 (PGE_1). Prostaglandin E_1 (PGE_1) has also been seen to be induced by mechanical stress and cause bone remodelling, Patil and his co-workers had shown that even minimal amounts of PGE_1 injection had significant increase in tooth movement [9]. Due to the hyperalgesia that accompanies with the local injection of PGE_1 , an analogue of it which is misoprostol was tried out. It was seen that it was effective in increasing orthodontic tooth movement (**Figure 1**) [10].

The parathyroid hormone (PTH) acts directly on osteoblasts and on osteoclasts indirectly by binding to the PTH type 1 receptor on osteoblasts. This causes the expression of insulin like growth factor 1. There is promotion of osteoblast survival, osteoblastogenesis and receptor activator for nuclear factor κ B ligand (RANKL) which induces osteoclast activation [2]. PTH facilitates bone remodelling in intermittent treatment by enhancing activities of osteoblasts and osteoclasts [11].

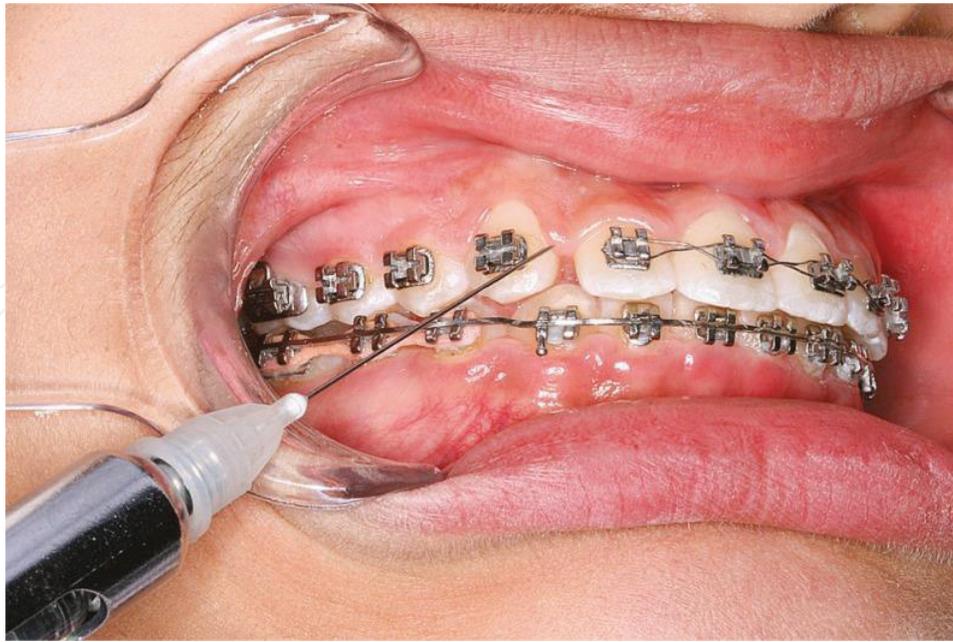


Figure 1. Injection of a biomodulator in the periodontium.

Calcitriol or 1,25-dihydroxycholecalciferol which is the most active metabolite of vitamin D acts in a similar fashion to PTH by facilitating osteoblastic proliferation and function [12]. Calcitriol facilitates alveolar bone remodelling which leads to increase in tooth movement while force application [6, 13].

Recently intravenous immunoglobulin (IVIg) preparations which are used in immunodeficient patients as replacement therapy. These preparations have been shown to induce COX-2 mediated PGE₂ and cytokine production [14, 15]. Future potential of these preparations could be used to modulate orthodontic movement via PGE₂ synthesis.

2.2. Surgical methods

Bichmalyr in 1931, put forward a surgical technique with orthodontic appliances for rapid correction of severe maxillary protrusion. First, wedges of bone were removed to reduce the volume for which the roots of the maxillary anterior teeth would require for retraction. K le further looked into this technique in 1959 by including special movements like crossbite correction and space closure. He believed that he was able to move bony blocks using the crowns of teeth as handles as the blocks were connected by only less-dense medullary bone [16]. Currently there are few surgical methods being practiced, they are:

- Periodontally accelerated osteogenic orthodontics
- Piezocision
- Micro-osteoperforations

In 2001, Wilcko et al. had introduced a method which combines corticotomy surgery and alveolar bone grafting which is referred to as accelerated osteogenic orthodontics or recently

termed as periodontally accelerated osteogenic orthodontics (PAOO) [16]. This procedure which enables rapid tooth movement is due to a healing event that was described by Frost [17] and termed as regional acceleratory phenomenon (RAP).

RAP is the acceleration of the normal regional healing process from the original injury. It usually occurs after osteotomy, bone-grafting procedure, arthrodesis and fractures and there might be involvement and activation of precursor cells required for healing at the injury site. RAP can increase both soft and hard tissue healing processes by two- to tenfold [17]. It usually starts in the first few days of injury, peaks at the first or second month and may last for 3–4 months [16].

Orthodontic treatment can be started 1 week before or within 2 weeks after the surgery. Surgery begins with flap reflection and decortication with low-speed round burs. Bone graft is then laid over these areas of corticotomies. The flaps are then closed and sutured [18]. Several studies have been done related to corticotomies, an example is one by Uzuner and her co-workers where they showed that canine retraction assisted by corticotomy had reduced duration of retraction by 20% ratio [19]. PAOO has shown to have reduced treatment time, produce lower cortical bone resistance leading to reduced root resorption, enhancement of post-orthodontic stability, increased bone support since there is supplementation of the bone graft. However, PAOO still has risks since it is an invasive procedure and is expensive [20–24].

Since the corticotomy procedure is still invasive, Dibart et al. introduced a new minimally invasive method called piezocision. Piezocision involves microincisions which are confined to the buccal side that allows the use of piezoelectric knife and selective tunnelling which enables hard and soft tissue grafting [25]. Piezocision is usually done a week after orthodontic appliance placement. The procedure involves vertical incisions made buccally and interproximally. The mid portion of the incision between the roots enables the piezoelectric knife to be inserted. A piezotome is then inserted in the gingival openings that were made and piezoelectrical corticotomy of 3 mm is made. Hard or soft tissue grafts can then be added via a tunnelling procedure (**Figure 2**) [26].



Figure 2. Piezocision.

Piezocision can be used as an adjunct to treat a number of malocclusions and aid in rapid orthodontic treatment in adults. Since it is much more minimally invasive than corticotomy, it is having high degree of patient acceptance, short surgical time and has less postoperative discomfort [25, 26]. Dibart and coworkers in 2013 showed that there was an increase in the rate of tooth movement in their animal study and preliminary human studies are being conducted to correlate with the animal studies [26, 27].

To further reduce the amount of invasive nature of surgical intervention, a method called micro-osteoperforation (MOP). It is procedure in which small pinhole-sized perforations are created within the alveolar bone surrounding the dentition. This initiates cytokine release to call in osteoclasts to increase bone resorption. Thus, acceleration of tooth movement occurs during orthodontic treatment. The site of perforation is within the attached gingiva and close to the target teeth on the mesial and distal aspect of the roots of the teeth which will be moved. The most favourable place for placement of the perforation is the buccal cortical plate but lingual plate can also be approached with a contra-angled appliance. Two to four perforations are ideal amounts with depths of 3–7 mm into the bone [28].

In 2013, Alikhani et al. showed that MOP increased expression of cytokines for osteoclast differentiation, increased canine retraction, reduced orthodontic treatment by 62% with mild discomfort in patients [29]. In an animal study, Alikhani and co-workers found that the expression of inflammatory markers and bone resorption was significant. Their human clinical trial found distalisation was twice as much with MOP than the forces alone [30].

2.3. Physical methods

Despite all the attempts in making surgical methods being minimally invasive, they still remain as an invasive procedure. This had led to discoveries in other tools that can accelerate tooth movement during orthodontic treatment. The two most common physical methods used in the present day are:

- Vibratory stimulus
- Low level laser therapy
- Low-intensity pulsed ultrasound

Bone has the ability to respond to the mechanical stimuli that is applied to it as a mechanism to withstand functional activity. Rubin et al. showed the rate of remodelling in mechanically loaded long bones have been increased following vibrations or low level mechanical oscillatory signals [31]. In 2008, Nishimura et al. did an animal study which gave an insight on how resonance vibration could be able to accelerate tooth movement through the expression of RANKL in the periodontal ligament [32].

A novel device that was introduced by OrthoAccel Technologies is the AcceleDent device. The device has an activator and a mouthpiece. The patient bites on the mouthpiece component when in use. The activator which is extraorally positioned generates and transmits vibrations

to the teeth. It can provide 0.2 N of vibration at 30 Hz for 20 minutes. It was fabricated to work in tandem with existing bracket systems and not replace them. The device produces cyclic forces to move teeth within the alveolus via accelerated bone remodelling [33]. Pavlin and co-workers in 2015 showed low-level cyclic loading with AcceleDent increased the rate of orthodontic movement (**Figure 3**) [34].

Another treatment modality to speed up orthodontic tooth movement is by the use of low-level laser therapy (LLLT). Laser irradiation on tissues has a biostimulating effect with not more than 1°C rise in local temperature. Biostimulation potency of laser irradiation utilised by treatment are called low-level laser therapy [35]. Other than accelerating tooth movement, LLLT can enhance stability of orthodontic mini-implants [36], reduce post-adjustment pain [37], and induce bone growth in midpalatal suture area following rapid maxillary expansion [38].

Studies done by Fujita et al. and Yamaguchi et al. showed that LLLT enhances osteoclastogenesis on the compressed side of teeth being moved. There was stimulation of RANKL and macrophage colony-stimulating factor [39, 40]. Coordination of bone remodelling had been facilitated by RANKL and osteoprotegerin following orthodontic force with LLLT. LLLT stimulates bone formation on the tension side [41]. Kim et al. observed osteopontin localisation in the periodontal tissue in their study subjects, indicating LLLT may stimulate osteogenesis as well in orthodontic treatment [42]. Although much findings show LLLT stimulates osteoblast and osteoclast function, further studies are still required to optimise the effect of LLLT on tooth movement (**Figure 4**) [43].



Figure 3. AcceleDent device.



Figure 4. Low-level laser therapy.

Apart from physical agents, low-intensity pulsed ultrasound (LIPUS) has also been suggested. It uses mechanical energy which passes through the tissues as acoustic pressure waves [44]. This leads to biochemical changes at molecular and cellular levels. It can increase the healing of both soft tissue and hard tissue [45]. LIPUS is usually used at frequency pulses of 1.5 MHz with 200 μ s pulse width, which is repeated at 1KHz a for 20 minutes a day with an intensity of 30 mW/cm² [46].

Recent studies on LIPUS using animal models by Xue et al. showed that there is induction of alveolar bone remodelling. The remodelling occurred due to an increase in the gene expression of HGF/Runx2/BMP-2 signalling pathway with LIPUS. This led to an increase in the velocity of tooth movement during orthodontic treatment [47]. El-Bialy et al. observed that LIPUS may reduce the root resorption that was orthodontically-induced by deposition of dentin and cementum to create a preventive layer from root resorption [48].

3. Conclusion

Over the years, the methods of reducing treatment time has risen along with its' demand. The options that are available on the orthodontist's plate are numerous ranging from surgical means to photostimulation. Much studies will still need to be done for newer methods to emerge and obtaining a clearer understanding on the methods that already exist. At present, the clinician should use all the knowledge obtained for deciding which treatment option is best for the patient to meet the healthcare needs of the patient and achieving an optimum treatment outcome.

Author details

Anand K. Patil^{1*} and Amrit Singh Maan²

*Address all correspondence to: akptimes7@gmail.com

1 Department of Orthodontics and Dentofacial Orthodontics, SDM College of Dental Sciences and Hospital, Karnataka, India

2 SDM College of Dental Sciences and Hospital, Dharwad, Karnataka, India

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