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Accelerated Orthodontics - Can the Orthodontic Treatment Time be Lessened?

Manash Jyoti Borah

Consultant Oral and Dental Surgeon, Beena Medical Hall, D. K. Road, North Lakhimpur, Lakhimpur, Assam, Pin: 787001, India
Email: *mborah35[at]gmail.com*

Abstract: ***Orthodontic tooth movement occurs when force delivered to a tooth is transmitted to the adjacent investing tissues stimulating certain mechanical, chemical, and cellular events within these investing tissues, bringing structural changes and tooth movement. Orthodontic treatment time is a concern of a patient undergoing orthodontic treatment. Extended treatment time has certain drawbacks like root resorption, dental caries and gingival recession. The purpose of this article is to evaluate the various methods used in orthodontics to hasten the orthodontic treatment procedures.***

Keywords: Orthodontic tooth movements, Accelerated Orthodontics, Interseptal alveolar surgery, corticotomy, corticision, Piezoicision, Microosteoperforations

1. Introduction

Orthodontic tooth movement occurs with the help of the mechanical forces which brings about changes in the periodontium surrounding the roots. A change in the surrounding periodontal ligament (PDL), creates resorption in bone on pressure side and deposition of bone on the tension side [1]. Orthodontic movement can be regulated by the size of the applied force and biological responses from the periodontal ligament [2]. Resorption and deposition of bone around the tooth occurs by induction of osteoclasts via the RANK-RANKL pathway and presence of various inflammatory mediators such as IL-1, IL-8, TNF-α etc. [3, 4, 5, 6]. Acceleration of tooth movement has also been attempted by surgical methods, which is based on the principle that when bone is irritated surgically, an inflammation cascade generates which causes increased osteoclastogenesis causing faster tooth movement. [7] Mechanical or physical stimulation causes remodeling of bone by inducing osteoclastogenesis by promoting RANK/RANKL pathway and induction of Mitogen Activated Protein Kinase (MAPK), c-fos and nitric oxide [8].

Methods to accelerate orthodontic tooth movement can be broadly divided into:

1) Drugs
2) Surgical Methods
3) Physical/Mechanical methods

1) Drugs:
   a) Parathyroid hormones
   b) Vitamin D
   c) Prostaglandin
   d) Relaxin

2) Surgical Methods:
   a) Interseptal alveolar surgery
   b) Corticotomy
   c) Corticision
   d) Piezoicision
   e) Microosteoperforations.

3) Physical/ Mechanical methods:
   a) Direct electric current
   b) Cyclic Vibrations
   c) Low level laser therapy

Drugs

Various Drugs have been used to accelerate orthodontic tooth movement. These include Vitamin D, Prostaglandin, interleukins, parathyroid hormones, misoprostal etc. But this drug carries certain side effects. e.g.: When Vitamin D is injected to periodontal ligament it increases the LDH and CPK enzymes, prostaglandin causes a generalized inflammation and root resoption. Hence till date there is no drug that can safely accelerate orthodontic tooth movement. [9, 10, 11]

What is RAP or PAOO?

Regional Acceleratory Phenomena (RAP) is local response to a noxious stimulus, which describes a process by which tissue forms faster than the normal regional regeneration process. By enhancing the various healing stages, this phenomenon makes healing occur 2–10 times faster than normal physiologic healing (Frost, 1983). [7]

Many studies have reported an increase in the activity of infl ammatory markers such as chemokines and cytokines in response to orthodontic forces. Chemokines play an important role in the recruitment of osteoclast precursor cells, and cytokines, directly or indirectly, through the prostaglandin E2 pathway and the RANK/RANKL pathway, leading to the differentiation of osteoclasts from their precursors cells into mature osteoclasts. Therefore, it is logical to assume that increasing the expression of these factors, by surgically irritating the bone should accelerate tooth movement. [3, 4, 5, 6]

Due to the irritation of bone surgically, a wound is created. This wound initiates a localised inflammatory response. Due to the presence of the inflammatory markers, osteoclasts migrate to the area and cause bone resorption and hence the tooth movement.

Surgical Methods

In 1931, Bichlmayr introduced a surgical technique for rapid correction of severe maxillary protrusion with orthodontic appliances. Wedges of bone were first removed to reduce the volume of bone through which the roots of the maxillary anterior teeth would need to be retracted. In 1959, Kole expanded on this philosophy by addressing additional movements, including space closure and crossbite correction. They suggested that bony blocks (bone-teeth unit) were created as a result of the corticotomy, hence causing faster tooth movement. This concept prevailed till 2001, when Wilcko et al showed a transient demineralization-remineralization process taking place after corticotomy. [12]

Inter-septal alveolar surgery:

Inter-septal alveolar surgery or distraction osteogenesis involves controlled and gradual displacement of surgically created fractures which is termed as sub-periosteal osteotomy by incremental traction that results in simultaneous expansion of soft tissue and the bone volume due to mechanical stretching of the osteotomy site. It is divided into the distraction of the dentoalveolar bone or distraction of periodontal ligament [13].

Procedure: At the time of extraction of premolars the inter-septal bone distal to the canine is undermined surgically. Eventually resistance on the pressure site will be reduced [14]. Bone distal to canine undermined inter-septally by 1 to 1.5mm.

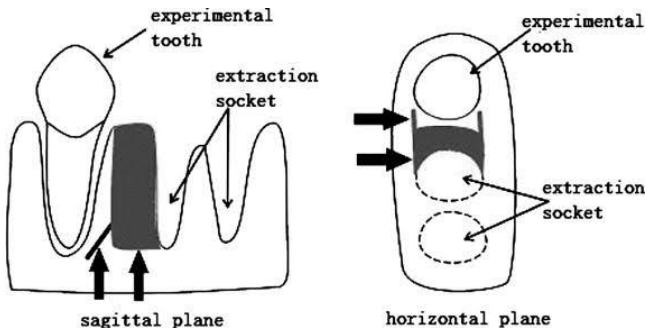

Figure 1: Inter-septal alveolar surgery for tooth movement

Corticotomy

The conventional corticotomy procedure involves elevation of full thickness mucoperiosteal flaps, bucally and/or lingually, followed by placing the corticotomy cuts using either micromotor under irrigation, or piezosurgical instruments. This can be followed by placement of a graft material, wherever required, to augment thickness of bone. [15]

Procedure: Elevation of full thickness of buccal and/or lingual mucoperiosteal flaps Positioning the corticotomy cuts using piezosurgical aurnamenterium or micromotor under irrigation and it is followed by placement of a graft material, in required sites to enhance the thickness of the bone [15].

Advantages: Bone can be augmented and periodontal defects would be avoided. Minimal changes in the periodontal attachment apparatus. Minimal treatment duration and increased rate of tooth movement. Less root resoption.

Disadvantages: Expensive and invasive procedure. May cause postoperative pain and swelling.

Figure 2: Corticotomy

Corticison

Park et al in 2006, and Kim et al in 2009, introduced the corticison technique, as a minimally invasive alternative to surgically injure the bone without flap elevation.

Procedure: Seperation of the inter-proximal cortices with a reinforced scalpel is used as a thin chisel and a mallet transmucosally without reflecting a flap. With 45°-60° an an inclination to the gingiva at the long axis of the canine a reinforced surgical blade with a minimum thickness of 400 µm should be located on the inter-radicular attachment. The surgical injury should be 2 mm from the papillary gingival margin in order to preserve the alveolar crest and should be 1 mm beyond the mucogingival junction. The blade should be pulled out by a swing motion. Clinical studies were conducted on humans [16] and animals [17] and concluded corticoincision fastens tooth movement similar to corticotomy and is advantageous because of its less invasiveness.

Micro-Osteoperforations (MOP)

To further reduce the invasive nature of surgical irritation of bone, a device called Propel, was introduced by Propel Orthodontics. They called this process as alveocentesis, which literally translates to puncturing bone. [18]

This device comes as ready-to-use sterile disposable device. The device has an adjustable depth dial and indicating arrow on the driver body. The adjustable depth dial can be positioned to 0 mm, 3 mm, 5 mm, and 7 mm of tip depth, depending on the area of operation. Previous animal studies have shown that performing micro-osteoperforations (MOPs) on alveolar bone during orthodontic tooth movement can stimulate the expression of infl ammatory markers, leading to increases in osteoclast activity and the rate of tooth movement.

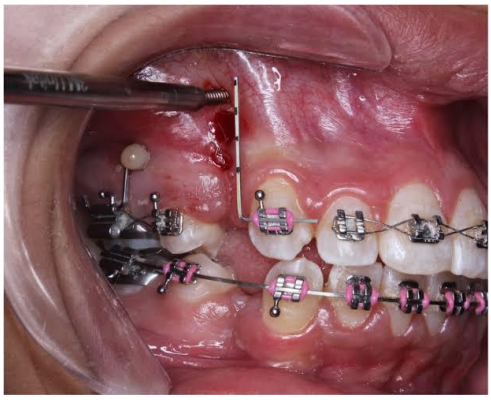

Figure 3: Micro-osteoperforation

Piezocision

This is a minimally invasive procedure involves flapless in combination of piezosurgical cortical micro-incisions with selective tunneling that allows for soft tissue or bone grafting [19]

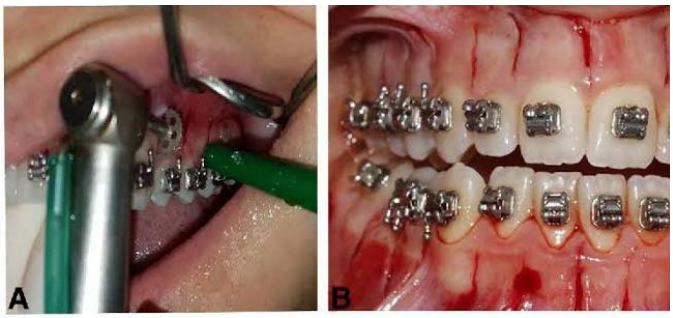

Figure 4: Piezocision

Vercelotti and Podesta established the use of piezosurgery instead of burs, in conjunction with the conventional flap elevations to create an environment conducive for the rapid tooth movement. This technique is quite invasive as it requires extensive flap elevation and osseous surgeries, with post-surgical discomfort. This technique has not been widely accepted by patient. Subsequently, Dibart introduced piezocision with less invasiveness to this procedure.

Mani Alikhani et al (2013), performed a single center single blinded study to investigate this procedure on humans. They found:

MOPs significantly increased the expression of cytokines and chemokines known to recruit osteoclast precursors and stimulate osteoclast differentiation.

MOPs increased the rate of canine retraction 2.3-fold compared with the control group.

- Patients reported only mild discomfort locally at the spot of the MOPs. At days 14 and 28, little to no pain was experienced.
- MOPs are an effective, comfortable, and safe procedure to accelerate tooth movement during orthodontic treatment.
- MOPs could reduce orthodontic treatment time by 62%.

Physical/Mechanical Stimulation

Surgical methods, regardless of technique, are still invasive to some degree, and hence have their associated complications. Hence, non-invasive methods have come to the fore. These modalities include lasers, vibration, direct electric current etc.

Low Level Laser therapy:

Low Level Laser therapy has stimulatory effects and can accelerate bone regeneration in midpalatal suture during rapid palatal expansion and stimulate the synthesis of collagen which is a major matrix protein in the bone. Low Level Laser therapy seems to be a good option for stimulatory options in the orthodontic tooth movement as it increases alveolar bone remodeling 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, shoed that the irradiated canines were retracted at a greater rate than the control canines by 34% over 60 days.

Figure 5: Low level laser therapy

Vibration

Nishimura et al in 2008, used a Ni-Ti expansion spring on the 1st molar of Wistar rats, and applied a vibration of 60 Hz, 1 m/s2. They stated that the rats that received the vibration showed increased orthodontic tooth movement. In the sectioned samples, they showed increased RANKL expression in the fi broblasts and osteoclasts of the periodontal ligament of the rats that received vibration. • Liu et al in 2009 conducted a study on thirty mice, in which they used an omega shaped Ni-Ti expander to deliver a force of 20 g on the 1st molar. Mechanical vibration (4 Hz for 20 min/day) was applied perpendicular to the occlusal surface of the fi rst molar. This regimen was repeated seven times, every 3 days. Upon micro-CT examination of the jaws of the killed mice, it showed that the mice that received vibration showed 40% more tooth movement. [20]

Figure 6: Vibration for tooth movement

Direct electric current

Electrical current has been tested experimentally on the animal models and have shown ATOM. Direct current or electrical currents generated piezoelectrically thereby enhance the OTM. Procedure: An electric appliance that provides direct electric current was placed in the extracted tooth region, generated bio electric potential causing local responses and acceleration of bone modelling. This procedure was performed by some researchers [21] on living animals and found to be effective in tooth movement. Subsequently, Kim [22] performed a clinical trial on humans and found 30% acceleration of tooth movement when compared to conventional technique.

Recently, a product by the name Acceledent has arrived at the market, which makes use of this technology. This device consists of an activator, which is the active part of the appliance that delivers the vibration impulses with a USB interface through which it can be connected to a computer to review the patient usage of the appliance, a mouthpiece that contacts the teeth. It is a portable device that can be charged similar to any other electronic device, and has to be worn for 20 minutes a day. Various case studies using this device have shown the treatment times to be reduced by up to 30-40%.

2. Conclusion

Orthodontic prolonged treatment time has been a concern for the patients undergoing orthodontic treatment. Recently a few techniques have lessen the treatment time considerably. Recent methods like micro-osteoperforations, lasers and vibrations have considerably reduced the invasiveness of Accelerated orthodontic procedures, to achieve the Regional acceleratory phenomenon. The rate of tooth movement increased considerably and hence decreasing the treatment time.

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