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Review Article

Methods of Accelerating orthodontic treatment – A Review

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ABSTRACT

Prolonged treatment duration is one of the main deterants in orthodontics. 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.Various methods have been introduced to enhance the rate of tooth movement which include surgical methods, mechanical stimulation methods and some drugs.The aim of this article is to enumerate and discuss different methods to accelerate orthodontic tooth movement.

Introduction

The Prolonged treatment duration is one of the main deterants in orthodontics. 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.[1] Fixed orthodontic treatment can last upto 2 to 3 years which further poses the risk of complications associated with the treatment such as external root resorption, periodontal problems and patient compliance. Clinicians are constantly striving towards developing potential strategies to enhance the rate of orthodontic tooth movement.[2]

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. The aim of this article is to enumerate and discuss different methods to accelerate orthodontic tooth movement and also to discuss advantages and shortcomings of each method.

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

1. Surgical Methods.
2. Device assisted therapy or Mechanical stimulation methods.
3. Drugs.

1. Surgical Methods

The surgical technique has been documented in many case reports. It is a clinically effective technique used for adult patients, where duration of orthodontic treatment may be critical. Periodontal ligament (PDL) and alveolar bone remodeling are the important

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parameters in tooth movement and bone turnover is known to increase after bone grafting, fracture, and osteotomy. Several surgical approaches that have been tried in order to accelerate tooth movement are Corticotomy and Piezocision technique.[3]

The idea of surgical acceleration came into being after the introductionof Regional Acceleratory Phenomena (RAP) by Frost in 1983. RAP is a local response to noxious stimulus, by which tissue forms faster than the normal regional regeneration process. This phenomenon causes healing to occur 2–10 times faster than normal physiologic healing by enhancing the various healing stages.[4]

Corticotomy

It was first tried inorthodontics by Kole.[5]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.[5]

The conventional corticotomy procedure involves elevationof full thickness mucoperiosteal flaps, bucally and/orlingually, followed by placing the corticotomy cuts using eithermicromotor under irrigation, or piezosurgical instruments.This can be followed by placement of a graft material,wherever required, to augment thickness of bone.[6]

Until 2001, the "bony block" concept prevailed as a misconception. However, Wilcko et al[7] reported that tooth movement was not the result of bony block, but rather a process of transient remineralization/demineralization which is a concept of reversible osteopenia in the bony alveolar housing consistent with wound healing pattern of RAP. He also introduced the term "bone matrix transportation" and developedpatent techniques which were called Accelerated OsteogenicOrthodontics (AOO) and Periodontal AcceleratedOsteogenic Orthodontics. Modification of RAP wasdone by adding bioabsorbable grafting material over theinjured bone to enhance healing.[7]

Advantages

1. Corticotomy procedure causes minimal changes in theperiodontal attachment apparatus.[8]
2. It has been proven successfully by many authors to accelerate tooth movement.[6,9]
3. Bone can be augmented; thereby preventing periodontal defects.[10]

Disadvantages

1. Invasive procedure leading to high morbidity.
2. Chances of damage to adjacent vital structures.
3. Postoperativepain and swelling.
4. Chances of infection or avascularnecrosis.
5. Low acceptance by the patient.[6, 11]

Corticision

Park et al introduced a technique named corticision which involved cutting the bone using scalpel and mallet through thegingiva without reflection of a surgical flap. The trauma tothe bone induced RAP, in turn leadingto rapid tooth movement. But this method had itsshortcomings involving dizziness in the patient due torepeated malleting.[12]

Piezocision technique

One of the recent techniques inaccelerating tooth movement is the Piezocision technique.[11]Dibart was amongst the first to apply thePiezocision technique which starts with primary incisionplaced on the buccal gingiva, below the interdental papilla, as far as possible, in the attached gingiva using a No.15 scalpel. These incisions need to be deep enough so as to pass through the periosteum and contact the cortical bone. Next, using ultrasonic instrumentation (they used a BS1 insert Piezotome), perform the corticotomy cuts to a depth of 3 mm through the previously made incisions. At the areas requiring bone augmentation, tunneling is performed using an elevator inserted between the incisions, to create sufficient space to accept a graft material. No suturing is required except for the areas where the graft material needs to be stabilized.[6, 13] Piezocisiontechnique does not cause any periodontal damage as reportedby Hassan.[14]The study by Keser concluded that this technique can be used with Invisalign which leads to abetter aesthetic appearance and also the treatment time is shortened. Piezocision is a promising toothacceleration technique because of its various advantageson the periodontal, aesthetic, and orthodontic aspects.

Interseptal alveolar surgery

Interseptal alveolar surgery or distraction osteogenesis is divided into distraction of PDL or distraction of the dentoalveolar bone; example of both is the rapid canine distraction.[4] In the rapid canine distraction of PDL, the interseptal bone distal to the canine is undermined surgically at the same time of extraction of the first premolars, thus reducing the resistance on the pressure site. In this technique, the compact bone is replaced by the woven bone, and tooth movement is easier and quicker due to reduced resistance of the bone.[15]These rapid movements are during the initial phases of tooth movement especially in the first week. The interseptal bone is undermined 1 to 1.5 mm in thickness distal to the canine after the extraction of the first premolar and the socket is deepened by a round bur to the length of the canine. The retraction of canine is done by activation of an intraoral device immediately after surgery. It has been shown that it took 3 weeks to achieve 6 to 7 mm of full retraction of the canine into the socket of extracted first premolars.[16]

In all the studies done, thistechnique showed accelerated tooth movement with no evidence of significant root resorption, ankyloses or root fracture.[4] However, there were contradictory results regarding the electrical vitality test of the retracted canines. Liou[16] reported that 9 out of 26 teeth showed positive vitality, while Sukurica reported that 7 out of 20 showed positive vitality aftersix months of retraction. So uncertainties regarding this technique still prevail.

Micro-Osteoperforations (MOP)

To further reduce the invasive nature of surgical irritation of bone, a device called Propel, was introduced by Propel Orthodontics. They termed this process as Alveocentesis which literally translates to puncturing bone. 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.[6]

Mani Alikhani et al (2013)[1]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.

1.Patients reported mild discomfort locally at the spot of the MOPs. At days 14 and 28, little to no pain was experienced.

2.MOPs are an effective, comfortable, and safe procedure to accelerate tooth movement during orthodontic treatment.

3.MOPs could reduce orthodontic treatment time by 62%.

4.However, this was the first study investigating the MOPs method and certain issues were not addressed, such as, effect on root resorption, number of perforations required, long term effects (this study had a duration of only 28 days).[1]

2. Device assisted therapy or Mechanical stimulation methods

One more concept for accelerating tooth movement is by using device-assisted therapy.Compared to surgical methods these techniques are less invasive.They include direct electric current, pulsed electromagnetic field, static magnetic field, resonance vibration, and low level laser which was mostly investigated and gave the most promising results.[4, 16]

The thought of using physical approaches came from the conceptthat 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.[17]

Cyclic forces

The principal behind the use of cyclic vibratory method is to place light alternating forces on the teeth via mechanical radiations.[16]Acyclic device was used to produce the vibration impulses of 20-30 Hz for 20 minutes each day in human teeth. These vibrations stimulated remodeling activity and brought about tooth movement at the rate of 2-3 mm/month. These devices are portable so they can be charged similar to any other electronic device. Various case studies using this device have shown that treatment times could be reduced by up to 30-40 %.[18]

With the advancement of research, a new oral vibrating device, the Acceledent has recently become commercially available. To explore the clinical effects of this device, Kau et al[16] conducted a clinical trial in which 14 orthodontic patients were recruited and instructed to use the device for 20 minutes daily for a period of 6 consecutive months. As a result, it was found that the total rate of movement for the mandibular arch was 2.1 mm per month and for the maxillary arch was 3.0 mm per month, which apparently is faster than the traditional finding of about 1.0 mm per month. Mao and co-workers found cyclical forces between 1 Hz and 8 Hz, with forces ranging from 0.3N to 5N, increased bone remodeling. Further research needs to be carried out to clearly identify the range of Hertz that can be used in these experiments to get the maximum desired results.

Low-level laser therapy

Low-level laser therapy (LLLT) is one of the most promising approaches today. Laser has a biostimulatory effect on bone regeneration which is seen in the midpalatal suture during rapid palatal expansion.[19] It also stimulates bone regeneration post fracture and in extraction sites.[20, 21] Laser light induces the proliferation of osteoclast, osteoblast, and fibroblasts, thereby affecting bone remodeling and accelerates tooth movement. The mechanism involved in the acceleration of tooth movement is the production of ATP and activation of cytochrome C. The low-energy laser irradiation enhances the velocity of tooth movement via RANK/RANKL and the macrophage colony-stimulating factor and receptor expression.[22]In 2004, Cruz et al was the first to perform a human study on the effect of low-intensity laser therapy on orthodontic tooth movement. They concluded that the irradiated canines were retracted at a rate 34% greater than the control canines over a period of 60 days.[23]There are a lot of contradictory results relatedto the LLLT. Therefore, more research is needed in order todifferentiate the optimum energy, wavelength and theoptimum duration for usage.

Direct electric current effect on tooth movement

Another approach to increase tooth movement is to use direct electric current. Thistechnique was tested only on animals by applying directcurrent to the anode at the pressure sites and cathode atthe tension sites (7 V). This generated local responsesleading to acceleration of bone remodeling as shownby group of investigators. Their studies were moresuccessful than the previous attempts because electrodeswere placed as close as possible to the moving tooth.The bulk of the devices and the source of electricitymade it difficult to be tested clinically. Several attempts were made to develop biocatalytic fuel cells to generateelectricity intraorally by the use of enzymes and glucoseas fuel.Further development of the direct electricdevice and the biocatalytic fuel cells should be carried out so that these can be tested clinically.

Electrical currents and Pulsed electromagnetic fields:

Electrical currents have been tested experimentally on animal models and have shown accelerated tooth movement. Electrical currents generated peizoelectrically or direct current and thereby enhance the rate of tooth movement. According to Davidovitch, mechanical stress induced electrical potentials in bone and activated the cells that participate in the remodeling process. Also, the electrical stimulation in conjunction with mechanical force can increases the rate of tooth movement.Pulsed electromagnetic fields are produced by an integrated circuit embedded in a removable denture (0.5 mt and 1 Hz, V8 hours per day overnight). The bulk of the devices used to generate electric currents is a major shortcoming of these procedures resulting in lack of application during routine practice.[24]

3. Drugs

Various drugs have been used since long to accelerate orthodontic tooth movement, and have achieved successful results.[25-27] These include vitamin D, prostaglandin, interleukins, parathyroid hormone, misoprostol etc. But, all of these drugs have some or the other unwanted adverse effect. 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 root resorption. Hence, as of today, no drug exists

that can safely accelerate orthodontic tooth movement.[6]

Conclusion

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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