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Accelerated orthodontics- A review article

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ABSTRACT

Prolonged treatment duration is one of the main deterrents 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. 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

Orthodontic treatment is long duration treatment, leading patients especially adults patients to avoid treatment or seek alternative options such as implants or veneers with less optimal results, therefore, the search for methods that decrease the treatment duration without compromising the outcome is a main challenge in orthodontic research. whereas clinicians – optimised treatment through careful diagnosis and treatment planning, as well as patient co-operation can affect treatment duration the, the main factor controlling

the rate of tooth movement is the biologic response to the orthodontic forces [1].

As there is prolonged treatment, duration in orthodontics it may result in increased risk of root resorption, dental caries and periodontal health problems. any method that will shorten the orthodontic treatment is desirable. Many attempts have been made to reduce orthodontic treatment duration including the development of new biomechanics techniques to move teeth efficiently and find methods of accelerating tooth movements. Suggested accelerating tooth movement methods are local injections with prostaglandins, osteocalcin, corticotomy, electric current

stimulation and pulsed electromagnetic field and also how level laser irradiation has gained interest for speeding up tooth movement [2].

Orthodontic tooth movement is possible due to the remodelling ability of the surrounding bone and soft tissue without this remarkable biologic phenomenon, the practice indeed, the very concept of orthodontics would not be possible. Orthodontic appliances are built to generate biomechanical force systems that produce the desired tooth and jaw movements needed to establish an ideal occlusion regardless of the cellular mediators of the response [3].

Accelerating orthodontic tooth movement and resulting shortening of the treatment duration would be quite beneficial [4].

Orthodontic forces induce a cellular response in the periodontal ligament, which brings about bone resorption on the pressure side and bone deposition on the tension side. This happens via induction of osteoclasts via the RANK-RANKL pathway and presence of various inflammatory mediators such as IL-1, IL-8, TNF-alpha, etc [5].

Methods to Accelerate Orthodontic Tooth Movement

- A. Surgical
- B. Mechanical
- C. Drugs

SURGICAL

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 teeth would need to be retracted. In 1959, Kole expanded on his philosophy by addressing additional movements, including space closure and cross bite [5].

The surgical techniques have been documented in many case reports. It is clinically effective technique used for adult patients, where duration of orthodontic treatment may be critical. Several surgical approaches that have been tried in order to accelerate tooth movement are corticotomy and piezocision technique [6].

The idea of surgical acceleration came into being after the introduction of 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 [6].

Corticotomy

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.

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

1. Corticotomy procedures have many advantages like Corticotomy procedure causes minimal changes in the periodontal attachment apparatus [8].
2. It has been proven successfully by many authors to accelerate tooth movement [5, 9].
3. Bone can be augmented; thereby preventing periodontal defects [10]. As the Corticotomy procedure has advantages it has disadvantages too like Invasive procedure leading to high morbidity.
4. Chances of damage to adjacent vital structures.
5. Postoperative pain and swelling.
6. Chances of infection or avascular necrosis.
7. Low acceptance by the patient [5, 11].

Cortision

Park et al in 2006, and Kim et al in 2009, introduced the cortision technique, as a minimally invasive alternative to surgically injure the bone without flap elevation [5].

Piezocision

To reduce the morbidity associated with conventional corticotomy, Dibart et al in 2009, introduced a flapless method of corticotomy, using piezosurgery [5]. One of the recent techniques

inaccelerating tooth movement is the Piezocision technique [5].

Piezocision technique does not cause any periodontal damage as reported by Hassan [6].

Piezocision is a promising tooth acceleration technique because of its various advantages on the periodontal, aesthetic, and orthodontic aspects [6].

The Piezocision technique which starts with primary incision placed 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 BSI 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 [5, 13].

Piezocision technique does not cause any periodontal damage as reported by Hassan [6].

There are also some advantages and disadvantages of piezocision. Advantages like minimal invasive, Better patient acceptance and disadvantages like risk of root damage

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. The concept of distraction osteogenesis came from the early studies [26] of limb lengthening. Also from surgical treatments of craniofacial skeletal dysplasia, this concept was later adapted in relation to the rapid tooth movement [2].

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, this will reduce the resistance on the pressure site. In this concept the compact bone is replaced by the woven bone, and tooth movement is easier and quicker due to reduced resistance of the bone.

In this technique 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 the canine is done by the activation of an intraoral device directly after the surgery. It has been shown that it took 3 weeks to achieve 6 to 7 mm of full retraction of the canine to the socket of the extracted first premolars.

Rapid canine distraction of the dentoalveolar bone is done by the same principle of the distraction of PDL, with the addition of more dissection and osteotomies performed at the vestibule as shown in [2].

Micro –Osteoperforations

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 [5].

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% [5].

MECHANICAL METHODS

Lasers

Lasers is an abbreviation of Light Amplification by Stimulated Emission of Radiation. Lasers have specific characteristics. They are produced in only a single wavelength (monochromatic), all in one phase (coherency) lead to a very high intensity light and with rays parallel to each other (collimation). Lasers are named according to their active mediums, which are used for producing

different types of light; for example, CO₂ laser is produced from CO₂ gas.

Indication LLLT is suggested in patients who are willing to attend multiple times with short intervals between laser applications. Contraindications of LLLT are cancerous and pre-cancerous lesion in the oral cavity. Irradiation laser to patient with coagulation disorders should be avoided due to its effect on blood flow. Patients with epilepsy are also contraindicated because they may have a seizure during irradiation. For patients who may have hyper- or hypothyroid conditions, irradiation over the thyroid gland should be avoided to prevent undesirable effects.

Adverse effects of LLLT There have been no reports that LLLT could cause root resorption, alveolar bone loss, and any adverse effects on oral mucosa, gingiva, periodontal ligament and vitality of the dental pulp [7].

Risks of LLLT

LLLT are classified as a class IIIb hazard which can damage the retina. If viewed directly or from reflective light, these lasers can be dangerous to unprotected eyes for any duration. Therefore, patient, practitioner and any person within the controlled area should wear appropriate eye protection. All protective glasses or goggles should be labeled with the wavelength, for which protection is given

Advantages

1. Non-invasive technique and reduction of post adjustment pain
2. No adverse effects to irradiated tooth and periodontium.
3. Easy to perform

Data from systematic review showed that there is some evidence that LLLT is effective. But such a conclusion should be interpreted with caution because the included studies have too small sample sizes, high degree of heterogeneity and moderate to high risks of bias [7].

Vibration method

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 %.With the advancement of research, a new oral vibrating device, the Aceledent has recently become commercially available [6].

Direct electric current effect on tooth movement Another approach is to use direct electric current. This technique was tested only on animals by applying direct current to the anode at the pressure sites and cathode at the tension sites (by 7 V), thus, generating local responses and acceleration of bone remodeling as shown by group of investigators [37]. Their studies were more successful than the previous attempts because electrodes were placed as close as possible to the moving tooth. The bulkiness of the devices and the source of electricity made it difficult to be tested clinically [6].

DRUGS

Various drugs have been used since long to accelerate orthodontic tooth movement, and have achieved successful results.8-10.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 causes root resorption. Hence, as of today, no drug exists that can safely accelerate orthodontic tooth movement [5].

Prostaglandins

Remodeling activities associated methods have arrived with the help of piezosurgery, with inflammatory reactions induced by mechanical fiberotomy, micro-osteoperforations, etc. which achieve stimuli form the biological basis for orthodontic tooth the same results as achieved by conventional movement [8].

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 [8].

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 [8].

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