Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 11, Issue, 02, pp.1711-1714, February, 2019

DOI: https://doi.org/10.24941/ijcr.34611.02.2019

ISSN: 0975-833X

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

REVIEW ARTICLE

ACCELERATED ORTHODONTICS, BRISK WITHOUT RISK: A REVIEW

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ARTICLE INFO

Article History:
Received 17th November, 2018
Received in revised form
22nd December, 2018
Accepted 13th January, 2019
Published online 28th February, 2019

Key Words:
Piezecision, orthodontics, Corticotomy.

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ABSTRACT

Background: The biggest concern of any orthodontic treatment is the amount of time which is required to complete the treatment. Prolonged treatment time could increase the risk of dental caries, periodontal diseases, and root resorption. Thus, accelerating orthodontic tooth movement (OTM) is one of the primary goals for orthodontists with optimum end results, which will ultimately shorten the treatment duration. When an orthodontic force is delivered to a tooth certain mechanical, chemical, and cellular events take place within the paradental tissues, which will allow architectural alterations and cause movement of that tooth. Any orthodontic treatment on an average requires 12-48 months for its completion, but by increasing body's response to the orthodontic forces the treatment duration can be reduced. Many methods are available to accelerate tooth movement, such as corticotomy, piezosurgery, vibration, lasers, drugs, magnets etc. These methods have been successfully proven to reduce treatment times by up to 70%. The purpose of this study is to view the successful approaches in tooth movement and to highlight the newest technique in tooth movement.

***Citation: Apurva Nikte, Urvashi Nikte, Vaidehi Arekar, Sushrut Niphadkar, Paritrat Prakash and Utsav Nikte,* 2019.** "Accelerated orthodontics, brisk without risk: A review", *International Journal of Current Research*, 11, (02), 1711-1714.

INTRODUCTION

Mechanical stimuli causes orthodontic tooth movement by remodeling alveolar bone and periodontal ligament (PDL). Bone remodeling causes bone resorption on the pressure site and bone apposition on the tension site (Davidovitch, 1991). Orthodontic tooth movement can be controlled by the amount of the force applied and the biological changes in the PDL (Meikle, 2006). The force applied on the teeth causes microenvironmental changes around the PDL due to alterations of blood flow, leading to the secretion of different inflammatory mediators such as cytokines, growth factors, neurotransmitters, colony-stimulating factors, and arachidonic acid metabolites. As a result of these secretions, remodeling of the bone occurs (Davidovitch *et al.*, 1988; Krishnan and Davidovitch, 2006). 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. Surgical methods were based on the principle that when the bone is irritated surgically, a cascade of inflammatory reaction is initiated that causes increased osteoclastogenesis, hence causing faster tooth movement (Regional Acceleratory Phenomenon (RAP) or Periodontally Accelerated Osteogenic Orthodontics (PAOO).

Newer surgical techniques like piezosurgery, fiberotomy, microosteoperforations etc. achieves the same results as achieved by conventional corticotomy, but with reduced invasiveness and morbidity. Methods to enhance OTM can be classsified into Drugs, Surgical methods and physical stimulation.

Methods to accelerate orthodontic tooth movement

Drugs

Prostaglandins: PGs are inflammatory mediator and a paracrine hormone that acts on nearby cells; it stimulates bone resorption by directly increasing the number of osteoclasts. Yamasaki (Yamasaki *et al.*, 1980; Yamasaki *et al.*, 1982) was among the first to investigate the effect of local administration of prostagladin on rats and monkeys. Furthermore, chemically produced PGE2 has been studied in human trials with split-mouth experiments in the first premolar extraction cases. In these experiments the rate of distal retraction of canines was 1.6-fold faster than the control side (Yamasaki *et al.*, 1984).

Vitamin D3: 1,25 dihydroxycholecalciferol is a hormonal form of vitamin D and plays an important role in calcium homeostasis with calcitonin and parathyroid hormone (PTH).

A comparison between local injection of vitamin D and PGEs on two different groups of rats was also investigated. It was found that there is no significant difference in acceleration between the two groups. However, the number of osteoblasts on the pressure side which was injected by vitamin D was greater than on the PGE2 side. This indicates that vitamin D may be more effective in bone turnover (Kale *et al*., 2004).

Parathyroid Hormone: PTH has been shown to accelerate orthodontic tooth movement on rats, which was studied by continuous infusion of PTH (1 to 10 μg/100 g of body weight/day) implantation in the dorsocervical region, and the molars were moved 2- to 3-fold faster mesially by orthodontic coil spring (Soma *et al*., 1999). Some studies have shown that locally injected PTH induces local bone resorption, and it is more advantageous to give PTH locally rather than systemically (Takano-Yamamoto and Rodan, 1990).

Relaxin: The role of relaxin is known in the remodeling of soft tissue rather than remodeling of bone. It has been shown that it increases collagen in the tension site and decreases it in compression site during orthodontic movement (Han *et al*., 2004; Bumann *et al*., 1997). The remodeling of PDL by relaxin might reduce the rate of relapse after orthodontic treatment as suggested by others (Masella and Meister, 2006). However, the mechanism of how relaxin accelerates tooth movement is not yet fully understood.

Surgical approach

Bichlmayr in 1931 introduced a surgical technique for rapid tooth movement, 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 suggested that bony blocks (bone-teeth unit) were created as a result of the corticotomy, hence causing faster tooth movement. In 2001, Wilcko *et al*. showed a transient demineralization-remineralization process taking place after corticotomy (Wilcko *et al*., 2001). This was termed as PAOO (Periodontally Accelerated Osteogenic Orthodontics). This concept was earlier described by Frost in 1983, and was called as RAP (Regional Acceleratory Phenomenon) (Frost, 1983).

Corticotomy: The conventional corticotomy technique involves elevation of full thickness mucoperiosteal flaps, bucally and/or lingually, followed by placing the corticotomy cuts using either micromotor or piezosurgical instruments which can be followed by placement of a graft material, wherever required, to augment thickness of bone. In 2001, Wilcko *et al*. reported that a surface-computed tomographic evaluation of corticotomized patients clearly showed a transient localized demineralization-remineralization process consistent with the accelerated wound-healing pattern of the RAP (5). Merits of this technique is that the bone can be augmented, thereby preventing periodontal defects, which might arise, as a result of thin alveolar bone. Demerits of this tecnique includes, high morbidity associated with the procedure, invasive procedure, chances of damage to adjacent vital structures, post-operative pain, swelling, chances of infection, avascular necrosis, low acceptance by the patient. 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. They used a reinforced scalpel and mallet to go through the gingiva and cortical bone. This technique did induce RAP effect, but had drawbacks such as; inability to place grafts, and the malleting procedure was shown to cause dizziness after surgery (Clínicas, 2013).

Piezocision technique: One of the latest techniques in accelerating tooth movement is the Piezocision technique (Dibart *et al*., 2011). Was among the first to apply the Piezocision technique which starts with primary incision placed on the buccal gingiva followed by incisions by Piezo surgical knife to the buccal cortex (Mittal and Singla, 2011). This technique can be used with Invisalign, which leads to a better aesthetic appearance and less treatment time as reported by (Keser and Dibart, 2011). Piezocision is one of the best tooth acceleration technique because of its various advantages on the periodontal, aesthetic, and orthodontic aspects.

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 (Alikhani *et al*., 2013). 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 inflammatory markers, leading to increases in osteoclast activity and the rate of tooth movement. Mani Alikhani *et al*. (2013), performed a single center single blinded study to investigate this procedure on humans. They used a Ni-Ti closed coil spring, delivering a constant force of 100 g to distalize the maxillary canine after first premolar extraction. The spring was anchored to a TAD distal to the second premolar, and attached to the canine using a power arm through the vertical slot of the canine bracket. Gingival crevicular fluid (GCF) samples were collected from each subject to evaluate the level of inflammatory response. GCF was collected before orthodontic treatment, immediately before the start of canine retraction, and at each subsequent visit, between 10AM and 12 noon. Alginate impressions were taken at the beginning of the study, immediately before canine retraction, and 28 days after canine retraction began to monitor the rate of tooth movement. They concluded their study by stating that MOPs significantly increased the expression of cytokines and chemokines known to recruit osteoclast precursors and stimulate osteoclast differentiation (Alikhani *et al*., 2013).

Physical/mechanical stimulation

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

Laser: Photobiomodulation or low level laser therapy (LLLT) is one of the most promising and safest approaches today. Laser stimulates bone regeneration, which has been shown in the midpalatal suture during rapid palatal expansion (21), and also stimulates bone regeneration after bone fractures and extraction site (Trelles and Mayayo, 1987; Takeda, 1988). It has been found that laser light stimulates the proliferation of osteoclast, osteoblast, and fibroblasts, and thereby affects bone remodeling and accelerates tooth movement. The mechanism involved in the acceleration of tooth movement is by the production of ATP and activation of cytochrome C, low-energy laser irradiation enhanced the velocity of tooth movement via RANK/RANKL and the macrophage colony-stimulating factor and its receptor expression (Karu, 2008). Gauri Doshi Mehta *et al*. in 2013 (Doshi-Mehta *et al*., 2012). In a split mouth design, used a laser at 800 nm for 10 sec on the canine, both bucally and lingually, which had to be distalized after first premolar extraction. They also aimed to study the analgesic properties of laser therapy. For analgesic purposes, the settings were adjusted to a wavelength of 800 nm, a continuous wave mode, an output power of 0.7 mW, and an exposure time of 30 seconds. For biostimulation, the parameters were set at a wavelength of 800 nm, a continuous wave mode, an output power of 0.25 mW, and an exposure time of 10 seconds. There was a highly significant positive difference in the rates of tooth movement on the experimental side compared with the control side. There was a significant decrease in the pain score recorded, using a Visual Analog Scale.

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/s^2. 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 fibroblasts 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 first 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 (Nishimura *et al*., 2008). 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% (Liu *et al*., 2010).

Direct electric current effect on tooth movement: 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 (Davidovitch *et al*., 1980). 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. Several attempts were made to develop biocatalytic fuel cells to generate electricity intraorally by the use of enzymes and glucose as fuel (Kakehi *et al*., 2007; Kolahi *et al*., 2009). Further development of the direct electric device and the biocatalytic fuel cells is needed to be done so that these can be tested clinically.

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.

Conflict of interest: The authors have nothing to disclose

Funding: None

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