ISSN Print: 2394-7489
ISSN Online: 2394-7497
IJADS 2020; 6(2): 116-119

www.oraljournal.com
Received: 25-01-2020
Accepted: 27-02-2020

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Methods of accelerating orthodontic treatment: A review

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Abstract
Orthodontic treatment is the reorganization of skeletal and dental tissues. The duration of orthodontic treatment is the primary concern of most patients. Unfortunately, long orthodontic treatment time poses several disadvantages like higher predisposition to dental caries, gingival recession and root resorption. Nowadays, there is an increased tendency for researches to focus on accelerating methods for tooth movement due to the huge demand for adults for a shorter orthodontic treatment time. Orthodontic treatment is based on the premise that when force is delivered to a tooth and thereby transmitted to the adjacent investing tissues, certain mechanical, chemical, and cellular events take place within these tissues, which allow for structural alterations and contribute to the movement of that tooth. Cytokine, PTH, vitamin D, and RANKL/RANK/ OPG show promising results; on the other hand, relaxin does not accelerate tooth movement, but increases the tooth mobility. Many methods are available to accelerate tooth movement, such as surgical methods (corticotomy, piezosurgery etc.), mechanical/physical stimulation methods (vibration, lasers), drugs etc.

Keywords: Accelerated orthodontic tooth movement, corticotomy, lasers, microosteoperforations, piezosurgery, vibration

Introduction
In present era there is precipitously increase in demand for orthodontic treatment especially among adult patients. The greatest challenge amongst the patients undergoing orthodontic treatment is the increased treatment duration. Orthodontic treatment is a long and a complex procedure. During an orthodontic tooth movement, certain mechanical, chemical and cellular events takes place in teeth and its surrounding tissues allowing structural changes that cause orthodontic tooth movement. Orthodontic force induces 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. [1-4]. Macrophage colony stimulating factor (M-CSF), Receptor activator of nuclear factor kappa B ligand (RANKL), and osteoprotegerin (OPG) by osteoblasts play key roles in tooth movement. A recent research has duly discovered some factors like cyclic adenosine monophosphate (cAMP), calcium, collagenase, prostaglandins (PGs) which play an important role in tooth movement.
The following methods were introduced to accelerate the tooth movement and thus shorten the duration of treatment time.
They are broadly classified into
1. Invasive methods
2. Non-invasive methods

Invasive methods	Non-invasive methods
1. Corticotomy	1. Laser
2. Piezocision	2. Photobiomodulation
3. Piezopuncture	3. Vibration
4. Micro-osteo perforations	4. Drugs
5. Distraction osteogenesis	5. Platelet rich plasma

Corticotomy and corticision

Brought into picture by L.C. Bryan in 1893. He proved that Corticotomy-facilitated tooth movement was indeed possible and was the first one to describe it. It was first tried in orthodontics by Kole, where tooth movements were achieved between 6 and 12 months. 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.

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 regional acceleratory phenomenon [5].

Advantages

1. Bone can be augmented and periodontal defects would be avoided.
2. Minimal changes in the periodontal attachment apparatus.
3. Minimal treatment duration and increased rate of tooth movement.
4. Less root resorption.

Disadvantages [6]

1. Expensive and comparatively invasive procedure.
2. May cause post-operative pain and swelling.
3. Chances of damage to adjacent vital structures.
4. 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. 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 [7].

Piezocision & piezopuncture

To reduce the morbidity associated with conventional corticotomy, Dibart *et al*. in 2009, introduced a flapless method of corticotomy, using piezosurgery [8].

Dibart 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. Piezocision technique did not cause any periodontal damage as reported by Hassan. Using ultrasonic instrumentation (they used a BS1 insert Piezotome), to perform the corticotomy cuts to a depth of 3 mm through the previously made incisions. At the areas requiring bone augmentation, tunnelling is performed using an elevator inserted between the incisions, to create suffi cient space to accept a graft material. No suturing is required, except for the areas, where the graft material needs to be stabilized. Patient is placed on an antibiotic, mouthwash regimen.

Advantages

1. Minimally invasive.
2. Better patient acceptance.

Disadvantages

1. Risk of root damage, as incisions and corticotomies are "blindly" done.
    - Jorge *et al*. in 2013, 14 suggested a method, called MIRO (Minimally Invasive Rapid Orthodontic procedure) by using metal wire as a guide to placement of the incisions, and subsequently the corticotomy cuts. He placed metal guides in between each tooth, perpendicular to the main arch wire, and took digital radiographs, to ensure that the metal guides did not project over the tooth roots [7].

Microosteoperforations

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 [9]. 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.

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

Distraction osteogenesis

Distraction osteogenesis was used as early as 1905 by Codivilla1 and was later popularized by the clinical and research studies of Ilizarov (1988) in Russia. A detailed procedure was given by Iseri *et al*. A horizontal mucosal incision was made parallel to the gingival margin of the canine and the premolar beyond the depth of the vestibule. Cortical holes were made in the alveolar bone with a small, round, carbide bur from the canine to the second premolar, curving apically to pass 3 to 5 mm from the apex. A thin, tapered, fissure bur was used to connect the holes around the root. Fine osteotomes were advanced in the coronal direction. The first premolar was extracted and the buccal bone removed between the outlined bone cut at the distal canine region anteriorly and the second premolar posteriorly. Larger osteotomes were used to fully mobilize the alveolar segment that included the canine by fracturing the surrounding spongious bone around its root off the lingual or palatal cortex. The buccal and apical bone through the extraction socket and the possible bony interferences at the buccal aspect that might be encountered during the distraction process were eliminated or smoothedbetween the canine and the second premolar, preserving palatal or lingual cortical shelves. The palatal shelf was preserved, but the apical bone near the sinus wall was removed, leaving the sinus membrane intact to avoid interferences during the active distraction process. The surgical procedure lasted approximately 30 minutes for each canine.

Laser

Laser has a biostimulatory effect on bone regeneration which is seen in the midpalatal suture during rapid palatal expansion and also stimulates bone regeneration after bone fractures and extraction site [10]. It reduce discomfort and pain promoted by trauma or even by the forces applied on the teeth by a biostimulation effect in the irradiated area. It has been found that laser light stimulates the proliferation of osteoclast, osteoblast, and fibroblasts, and thereby affects bone remodeling and accelerates tooth movement. Increased osteoblastic and osteoclastic activity after low-level laser therapy was observed *in vivo* and *in vitro*. The mechanism involved in the acceleration of tooth movement is by the production of ATP and activation of cytochrome C, as shown in that low-energy laser irradiation enhanced the velocity of tooth movement via RANK/RANKL and the macrophage

colony-stimulating factor and its receptor expression [11].
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 [12].

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 fibroblasts and osteoclasts of the periodontal ligament of the rats that received vibration [13].

Drugs
Various drugs have been used since long to accelerate orthodontic tooth movement, and have achieved successful results [14-16]. 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 [17-18].

Drugs increasing rate of tooth Movement	Drugs decreasing rate of tooth Movement
Prostaglandins	NSAID's
Vitamin D	Fluorides
PTH	Bis-phosphonates
Thyroid hormone	Estrogen
Corticosteroids Relaxin	Calcitonin
No effect on tooth movement	Acetaminophen

Platelet rich plasma
Peripheral blood contains 94% of red blood cells (RBCs), 6% of platelets, and <1% of white blood cells (WBCs), while PRP contains 5% of RBCs, 1% of WBC, and 94% of platelets. PRP has been applied in dentistry for its capability of enhancing osseointegration of a dental implant and augmentation of alveolar bone height in maxillary sinus lift a suitable PRP for orthodontic purposes should be injectable and has a long lasting effect. To develop an injectable PRP with a prolong effect on the target tissue, a simple approach is to prepare the PRP without mixing with CaCl2 and thrombin, so that it could be maintained in a liquid form and be injectable. A single injection of PRP lasts for 5–6 months clinically. It has been observed clinically that the fastest rate of acceleration is during the second to fourth month after the injection. The submucosal injection of PRP is a clinically feasible and effective technique to accelerate orthodontic tooth movement and at the same time, preserve the alveolar bone on the pressure side of orthodontic tooth movement, and the optimal dose of PRP for the best clinical performance is 11.0–12.5 folds.

Conclusion
The current methods such as piezocision, microosteoperforations, lasers and vibration have reduced or eliminated the invasive nature of previous procedures used to achieve the Regional Acceleratory Phenomenon. Also, they come with additional advantages such reduced rates of relapse, reduced orthodontic pain and reduced root resorption. With time there will surely be more advances but till then we have prepared a faster route to improve the way our patients look by the faster means of tooth movement.

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