Review Article

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Accelerated Orthodontic Tooth Movement: A Review.

Abstract:
Accelerated orthodontic tooth movement is considered as one of the main concept in orthodontics for research. The duration of orthodontic treatment remains the primary concern for most of the patients. Increased treatment time leads to avoidance of orthodontic treatment. In the era of technology, many advances are made and newer techniques for accelerating orthodontic treatment have been introduced in order to reduce the length of treatment with minimal risk of side effects. The purpose of this article is to describe various methods used to accelerate the tooth movement orthodontically. The clinician should understand the biological rationale and potential effects of accelerating orthodontic tooth movement.

Keywords: Orthodontic treatment, Tooth movement, Accelerated orthodontics.

Introduction:

Orthodontic tooth movement occurs under mechanical forces leading to remodelling changes in dental and paradental tissues. This force creates a response in cellular component of periodontal ligament, that leads to resorption of bone on the pressure side and apposition of bone on the tension side.[1] The activation of osteoblasts and osteoclasts results in remodelling of supporting structures to influence orthodontic tooth movement.[2] Application of orthodontic force leads to alteration of blood flow around the surrounding tissue, which reduces the oxygen level at the pressure side.[3] This event leads to release of different inflammatory mediators like colony stimulating factors, cytokines, growth factors, arachidonic acid metabolites and neurotransmitters as a result of which remodelling of bone occurs.[1,2]

In today's modern society, people are more aware regarding their looks. This has increased the demand of orthodontic treatment among young individuals. But the duration of treatment remains the major concern for them. The time required for completion of orthodontic treatment depends on various factors. These factors can broadly be categorized as patient factors, diagnostic characteristics, treatment modality factors and patient compliance. [4]

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The amount of force delivered to a tooth and also the area of the periodontal ligament over which the force is distributed are important in determining the biologic effect. Long term comprehensive orthodontic treatment is dictated by biologic processes as well as mechanical principles and treatment approaches. The challenge for an orthodontist is to determine an acceptable treatment option without compromising the outcome.

Kole[5] was the first to propose Corticotomy Assisted Orthodontic Treatment (CAOT) as a process of accelerating tooth movement. In CAOT, perforations of only the cortex are performed leaving the medulla intact and rapid tooth movement is due to increased bone turnover as a response to the surgical procedure.

A cascade of inflammation is initiated around the bone which is irritated surgically. This procedure causes increased

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osteoclastogenesis thereby decreasing the mechanical resistance and causing faster tooth movement. This phenomenon is known as Regional Acceleratory Phenomenon (RAP).[5] A zone of high bone turnover with high osteoclastic and osteogenic activity is created that accelerates the speed of bone remodeling, thus accelerating the treatment.[6] The purpose of the present article is to narrate and outline the various methods of accelerating orthodontic treatment.

Methods To Accelerate Teeth Movement:

Various methods of accelerating orthodontic tooth movement can be broadly categorised as:

I. Surgical methods

a) Corticotomy
b) Periodontally Accelerated Osteogenic Orthodontics (PAOO)
c) Piezocision
d) Micro-osteoperforation
e) Interseptal alveolar surgery
f) Corticision
g) Sugery first approach

II. Physical/Mechanical methods

a) Low level laser therapy
b) Cyclic/ Resonance Vibration
c) Electric current
d) Electromagnetic field
e) LED device: Biolux
f) Therapeutic Ultrasound: Aevo system
g) Self ligating brackets

III. Drugs

a) Prostaglandin
b) Vitamin D3
c) Parathyroid hormone
d) Relaxin

I. Surgical Methods:

a) Corticotomy

Corticotomy is a surgical procedure which is performed by reflecting a full thickness mucoperiosteal flap in which cortical bone is perforated without entering into the medulla. In 1959, Kole[5] combined corticotomy with osteotomy to accelerate the tooth movement. Subsequently, only corticotomy was found efficient in increasing tooth movement.[7] Alveolar decortication increases bone turnover resulting in transient osteopenia, thereby increasing tooth movement by 2-fold during first few weeks after the procedure.[8]

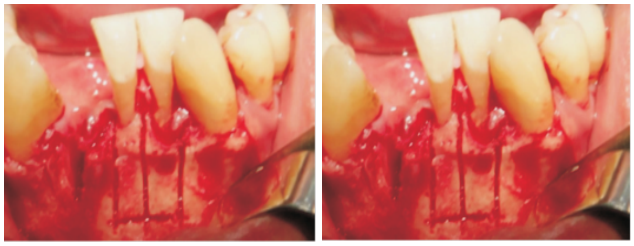

Fig 1: Corticotomy

Vertical grooves are made using a high-speed handpiece with a No.1 or No. 2 round bur, in the inter-radicular portion of the alveolar bone. These grooves are made on both labial/buccal and palatal/lingual aspects which start 2 to 3mm from the crest of the alveolar bone and extend upto 2mm apical to the root apices. Care should be taken to avoid neurovascular trauma.[9] (Figure 1)

b) Periodontally Accelerated Osteogenic Orthodontics (PAOO):

PAOO is an integrated technique of corticotomy facilitated tooth movement and alveolar augmentation. Bone grafts are used in this procedure in order to increase alveolar bone volume after orthodontic treatment, thereby correcting the pre-existing bony defects. PAOO decreases the treatment time to 1/3rd to 1/4th of conventional orthodontic treatment. The particulate bone graft used increases the limit of tooth movement, decreases the need for extraction and increases post treatment stability. Less chance of root resorption with rapid recovery and alveolar reshaping are reported with this procedure.[10] The complications associated with surgery like pain, swelling and hematoma can decrease the patients acceptance for the procedure. (Figure 2)

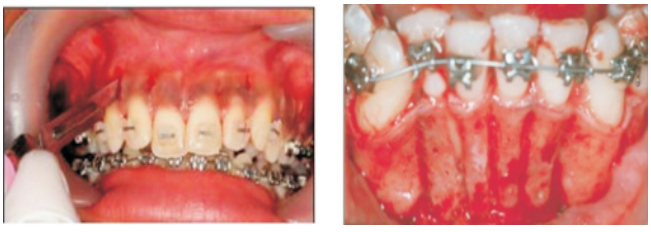

Fig 2: Periodontally accelerated osteogenic orthodontics

c) Piezocision:

In contrast to corticotomy, piezocision introduced by Vercelloti and Podesta[11] (2007), is a minimally invasive procedure that does not involve raising a full-thickness flap. To reduce surgical trauma, a piezo-electric knife is used instead of a high speed surgical bur. Using a No. 15 scalpel, gingival vertical incisions are made on the buccal aspect just below the interdental papilla in the attached gingiva. A 3mm deep piezoelectric corticotomy is done through the previously made incisions. If bone augmentation is required, it also has the advantage of allowing for graft placement via selective tunnelling using elevators. Minimal trauma and discomfort from the procedure enhances patient's acceptance and the procedure is equally effective in accelerating orthodontic tooth movement. (Figure 3)

Fig 3: Piezocision

d) Micro-osteoperforations (MOP):

Also known as alveocentesis, it is the least invasive procedure in which micro-trauma is induced to the alveolar bone thus producing RAP, which in turn increases the rate of orthodontic tooth movement.[12] The procedure can be performed with the help of PROPEL device. (Figure 4)

Fig 4: Propel

MOPs are done just before commencement of the desired tooth movement and are performed close to the target teeth. The procedure is very simple to perform with zero recovery time and significantly reduces the duration of orthodontic treatment.[13] (Figure 5)

Fig 5: Alveolar Micro osteoperforations

e) Interseptal alveolar surgery

This procedure is based on the principle of Distraction Osteogenesis. It can be achieved either by distraction of PDL or dentoalveolar distraction. Immediately following the extraction of first premolar, 1 to 1.5mm interseptal bone distal to the tooth (to be moved) is surgically undermined. This reduces the resistance at pressure site as compact bone is replaced by woven bone.[14]

f) Corticision:

Also known as Minimally Invasive Rapid Orthodontics (MIRO), it was introduced in 2009 by Kim and co-workers[15] as a minimally invasive technique and an alternate to the surgical procedures. A reinforced scalpel and a mallet are used to cut the bone through the gingiva without reflecting the mucoperiosteal flap. The trauma to the bone induces regional acceleratory phenomenon which leads to accelerated tooth movement.

g) Surgery first approach

For patients requiring orthognathic surgery for the correction of severe dento-facial deformities, surgery first approach significantly reduces the duration of treatment as the time consuming phase of decompensation is eliminated. Liou[16] reported a significant decrease in overall treatment duration as the procedure stimulated regional acceleratory phenomenon around the surgical wound.

I. Physical Methods

a) Low Level Laser Therapy (LLLT):

Low level Laser Therapy also known as Photobiomodulation increases orthodontic tooth movement by stimulating the formation of osteoblasts, osteoclast and fibroblasts and thereby affect bone remodelling. The mechanism involved in the acceleration of tooth movement is by the production of ATP and activation of cytochrome-C which in turn activates RANKL-RANK and macrophage colony stimulating factor expression. Laser wavelength of 800nm and output power of 0.25mW for 10 sec has been shown to accelerate tooth movement 1.3-1.5 times the control side.[17] LLLT is easy to use localised, non-surgical, non-invasive method and is hence gaining popularity in AOTM.

b) Cyclic/Resonance Vibration:

Resonance vibration is based on a frequency equal to the natural frequency of the object.[26] It provides micro-impulses which fastens the tooth movement by activating the cellular and molecular mechanism and increasing the activity of the PDL cells. Acceledent is the device used for providing vibrations which provides vibration with only 1 fixed frequency (4Hz) and should be used for 20 minutes per day.

c) Electric current

A constant electric current of 15μA when applied for 14 days in cats was found to significantly increase the orthodontic tooth movement.[18] The electricity increased the amount of bone turnover by enhancing osteoclast accumulation on the compression side and osteoblast accumulation on the tension side.A systematic review conducted by Agrawal and Co-workers[19] concluded that electric stimulation combined with induced tooth movement favours tissue response which is effective for increasing the rate and amount of orthodontic tooth movement. Further studies, human trials and research are required in this field to optimize an electric device that could be used during active orthodontic treatment.

d) Electromagnetic field

Darendeliler and co-workers[20] studied the effect of samarium-cobalt magnets and pulsed electromagnetic fields on tooth movement in guinea pigs and found an increase in the rate of tooth movement due to reduction in the 'lag' phase. An appreciable amount of organisation and new bone deposition was found on the tension side. Showkatbakhsh and co-workers[21] conducted a study on patients requiring canine retraction who were exposed to a pulsed electromagnetic field of 1 Hz and it was seen that canine retraction was 1.57 ± 0.83 mm more than the control group which suggested that the application of pulsed electromagnetic field can accelerate tooth movement.

e) LED Device: Biolux

An intraoral device named Biolux, patented in late 2010, utilizes tissue penetrating light to accelerate tooth movement. The device uses 800-850 nm wavelength light adjacent to the alveolar bone. The light energy used penetrates the soft tissue and gets directly infused into the bone tissue. The photochemical interaction of light with tissue, can cause excitation of intracellular enzymes and increased cellular activity in the PDL and bone thus increasing the rate of bone remodelling and tooth movement. A few studies[22,23,24] reported significant positive results while Chung et al[25] found no significant result for AOTM in retraction phase using BIOLUX LED Device.

f) Therapeutic Ultrasound: Aevo system

A low-intensity therapeutic pulsed ultrasound –the Aevo device, marketed by SmileSonica of Canada, increases the blood flow in the PDL, thereby increasing bone remodelling and tooth movement and also decreases root resorption.[26] El-Bialy T et al[27] reported that patients who used Low-Intensity Pulsed Ultrasound showed a clinically significant reduction in the overall orthodontic treatment duration and minimized orthodontically induced root resorption at the same time.

g) Self-ligating brackets

Self-ligating brackets are claimed to reduce treatment time and also to provide more efficient treatment outcome as it allows for efficient sliding mechanics by reducing the friction between archwire and bracket and therefore, more rapid tooth movement. However, in recent studies, no significant role of self-ligating bracket is found in reducing the overall treatment time.

II. Pharmacological Methods

Various drugs have been used since long to accelerate orthodontic tooth movement and have achieved successful results. Vitamin D, Prostaglandin, Parathyroid hormone and Relaxin are the most commonly used pharmacological agents to increase tooth movement.

a) Prostaglandins:

Prostaglandins are inflammatory mediators that stimulate bone resorption by increasing directly the number of osteoclasts. Patil et al. [28] (2005)conducted a clinical trial to verify the effect of exogenous application of Prostaglandin E1 on Orthodontic tooth movement. The method of administration was in the form of local infiltration in the vestibular area at the upper canine region. Significant increase in the tooth movement was observed on experimental side when compared to the control side.

b) Vitamin D3:

Vitamin D3 increases the absorption of calcium from small intestine and thus maintains calcium homeostasis. Experimental studies have shown that Vitamin D3 leads to increased turnover of osteoclasts thereby leading to more bone resorption,[29] thus increasing orthodontic tooth movement. Further studies on humans are needed to determine the efficacy of Vitamin D in accelerating tooth movement.

c) Parathyroid hormone(PTH):

Animal studies have shown that local injection of PTH increases the orthodontic tooth movement by 1.6 to 2 fold by accelerating osteoclast turnover.[30] Long term administration of parathyroid hormone leads to pathologic changes in kidneys and bones and therefore parathyroid hormone should be administered in a controlled manner for a short duration. Experiments validating the effect of parathyroid hormone in accelerating tooth movement in humans are limited and needs to be authenticated on humans.

d) Relaxin:

Relaxin is a hormone of insulin family which is produced in mammals during child birth. Relaxin influences many physiological processes such as collagen turnover, angiogenesis and antifibrosis both in males and females. Relaxin increases collagen in the tension side and decreases it in the compression side. Randomised controlled trial on humans have not shown any major advantage of using Relaxin for accelerating orthodontic tooth movement.

Conclusion

In today's busy schedule, reducing the treatment time and complications associated with treatment remains a challenging task for an orthodontist. A noticeable improvement in the duration of orthodontic treatment can be brought about by the use of advanced techniques. The clinician needs to build a wide knowledge regarding the procedures which can be performed depending upon the need of the case. All these techniques have drawbacks and uncertainties which warrant the need to carry out in depth research and well controlled trials to better understand the molecular mechanisms underlying accelerated orthodontic tooth movement and to be able to draw valid conclusions.

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