Journal of Advanced Medical and Dental Sciences Research

@Society of Scientific Research and Studies

Journal home page: www.jamdsr.com doi: 10.21276/jamdsr Index Copernicus value = 82.06

(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805

Review Article

Regional Acceleratory Phenomenon: A Review

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ABSTRACT
Long treatment time is one of the main drawbacks of orthodontic treatment. Patients also have a higher predisposition to dental caries, gingival recession and root resorption. Over the years researchers have introduced methods to accelerate the tooth movement. These methods are based on the concept of regional acceleratory phenomenon (RAP). According to this concept, orthodontic force applied on the tooth surface depends on various chemical, cellular and mechanical components, altering the biomechanics of tooth movement at these levels can alter the rate of orthodontic tooth movement. This article briefly explains the concept of RAP and various method to achieve it in clinical orthodontics.
Key words: Regional, Acceleratory, Phenomenon.

Received: 2 November, 2019 Accepted: 22 January, 2020

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This article may be cited as: Vattikunta N, Brar A, Potdar S, M Ramees M, Avirachan TV, Bhure N, Tiwari RVC. Regional Acceleratory Phenomenon: A Review. J Adv Med Dent Scie Res 2020;8(2):151-154.

INTRODUCTION

The periodontal ligament, alveolar bone and cementum which collectively form the periodontium play a critical role in determining rate of orthodontic tooth movement. Osteocytes, osteoblasts and osteoclasts bring about bone remodelling where the osteocytes function as a sensor of mechanical loading and initiate bone remodelling process involving the osteoblasts and osteoclasts.[1] The osteoclastic activity is a rate-limiting step determined via the RANK-RANKL pathway and presence of various inflammatory mediators such as IL-1, IL-8, TNF-alpha.[2]Any attempt to alter the course of orthodontic treatment should be focused around osteoclast and on the various processes by which osteoclast are recruited and differentiated to initiate bone resorption. Over the years several attempts have been made to reduce the overall treatment time of fixed orthodontics.

HISTORICAL PERSPECTIVE

Orthodontists have developed potential strategies to accelerate the orthodontic tooth movement based on the concept of regional acceleratory phenomenon (RAP) first described by Harold Frost. Historically, this concept was first introduced by Bichlmayr in 1931 where severe maxillary protrusion was corrected by removing bone wedges through which roots of the maxillary anterior teeth would need to be retracted. In 1959 Kole developed further on this philosophy by addressing additional movements, including space closure and crossbite correction. They suggested that bony blocks (bone-teeth unit) were created as a result of the corticotomy, hence causing faster tooth movement. The latest concept as proposed by Wilcko et al in 2001 states that a transient demineralization-remineralization process takes place after corticotomy. This was termed as PAOO (Periodontally Accelerated Osteogenic Orthodontics).[3]

BIOLOGICAL RATIONALE

Regional Acceleratory Phenomena (RAP) is local response to a noxious stimulus, which describes a process by which tissue forms faster than the normal regional regeneration process. Studies have reported an increase in the activity of inflammatory markers such as chemokines and cytokines in response to orthodontic forces. It is proposed that surgical irritation of bone increases the expression of these factors, which in turn should accelerate the tooth movement. A histological study by Sebaoun et al 2008 showed that selective alveolar decortication induced increased turnover of alveolar spongiosa. Surgery results in a substantial increase in alveolar demineralization leading to osteopenia which enables rapid tooth movement. As long as tooth movement continues, RAP continues. When RAP dissipates, the osteopenia disappears and the radiographic image of normal spongiosa reappears. On completion of orthodontic tooth movement, process of alveolar re-mineralization initiated again. [4]

VARIOUS APPROACHES TO RAP

Methods to accelerate orthodontic tooth movement can be broadly discussed under

I. Drugs.
II. Surgical Methods.
III. Physical/ Mechanical stimulation methods.

I. Drugs

Vitamin D, prostaglandin, interleukins, parathyroid hormone, misoprostol etc. are known to increase the rate of orthodontic toot movement. Vitamin D and parathyroid hormone function play an important role in bone remodelling by controlling calcium resorption. Animal studies have shown that both these drugs when applied accelerate the orthodontic tooth movement. Soma et al suggested that continuous administration of PTH accelerated orthodontic tooth movement in rats. Similar results were obtained with Vitamin D which increases LDH and CPK enzymes. However the results of these short term studies cannot be extrapolated to human models as its long term affect on kidney function and long bones has not been explored yet. Hence local administration using controlled release systems need to be developed.[5] Inflammatory mediators like prostaglandins when administered locally bring about increased production of osteoclasts which brings about bone resorption thus contributing to accelerated tooth movement. Yamasaki et al reported signficant increase in orthodontic tooth movement on administration of PGE in animal and human models. Relaxin hormone plays a role in remodelling the soft tissue by increasing the collagen at tension site and decreasing it at pressure site. Local administration may not sufficiently alter the orthodontic tooth movement, may even lead to adverse effects like root resorption. Till date no drug exists which can safely alter the orthodontic tooth movement.[6]

II Surgical Approaches

1. Corticotomy

A full thickness mucoperiosteal flap is elevated to place the corticotomy cuts or perforations only in the cortical bone without involving the medullary bone. These corticotomy cuts are placed using micromotor under irrigation or piezosurgical instruments. A graft material can be placed to increase the thickness of bone. This procedure causes minimum changes in the periodontal attachment apparatus and increases the rate of tooth movement within a short time duration.[7] Clinical trials reported a 28%-33% reduction in treatment time and 2-3 fold increase in tooth movement. However this is an invasive procedure with a high morbidity rate, hence has a low acceptance among patient.[8]

2. Corticision

Corticotomy was modified to make it less invasive. Inter-proximal cortices are separated using reinforced scalpel and mallet transmucosally without reflecting a flap. The incision is placed 2mm away from the papillary gingival margin o preserve the alveolar crest and 1 mm beyond the mucogingival junction. Studies show increased tooth movement and is a preferred method over corticotomy as it is less invasive.[9]

3. Piezocision

This minimally invasive procedure was introduced by Dibart et al in 2009 which involves flapless piezosurgical cortical micro-incisions along with soft tissue tunnelling to facilitate soft or hard tissue grafting. The incisions are placed upto the cortical bone and the corticotomy was done upto 3mm in depth using piezotomes. This technique is minimally invasive and can be combined with invisalign to achieve faster results.[10]

4. Minimally invasive rapid orthodontic (MIRO)

This technique was introduced by Jorge et al to overcome the disadvantage of risk of tooth damage

with piezocision. Digital radiographs were taken using metal wire as a guide to mark the incision thus reduced the risk of tooth damage.[11]

5. Micro-Osteoperforations (MOP)

To reduce the invasive nature of surgical irritation of bone, Propel Orthodontics introduced a device called Propel and termed the process as Alveocentesis. The device has an adjustable depth dial that can be positioned at 0mm, 3mm, 5mm and 7mm of tip depth and indicating arrow on the driver body. Mani Alikhani et al (2013)performed a single center single blinded study to investigate this procedure on humans. They concluded that MOPs increased the expression of cytokines and chemokines known to recruit osteoclast precursors and stimulate osteoclast differentiation. They increased the canine retractions by 2.3 times and reduced the treatment time by 62%.[12]

Surgical techniques require patient cooperation. Minimally invasive techniques such as piezocision and microosteoperforations are preferred for accelerating orthodontic tooth movement.

III. Physical/Mechanical Stimulation

Physical and/or mechanical stimulation of the bone is based on the bone bending theory where application of orthodontic forces causes bone bending leading to development of bioelectric potential.

1. Direct electric current

Direct electric current is provided by an electric appliance placed in the extracted tooth region, which generates bio electric potentials to accelerate bone remodelling. A clinical trial conducted by Kim et al reported 30% acceleration of tooth movement when compared to conventional technique.[13]

2. Cyclic vibrations

This is based on the concept of placing light alternating forces on the teeth via mechanical radiations. Amplified signals from the force sensor and the accelerometer are transferred to the vibrator which is fixed on the tooth with an adhesive. The vibration tests were carried out for 5 minutes, and the resonance curves were displayed as frequency-force relationships on the monitor of the vibration controller.[14]Clinical trials conducted using oral vibrating devices such as AccledentTM, AcceleDent® and electric tooth brushes reported effective increase in the rate of tooth movement.[15]

3. Low-level laser therapy

Photo biomodulation or low-level laser therapy (LLLT) is one of the most promising approaches today. Laser light stimulates the proliferation of osteoclast, osteoblast and fibroblasts, and thereby affects bone remodeling and accelerates tooth movement. It can accelerate bone regeneration in the midpalatal suture and stimulate the production of collagen. [16] Cruz et al in 2004 was the first to report the irradiated canines retracted 34% more than control canines over 60 days. [17] Gauri Doshi Mehta et al in 2012 conducted a split mouth design using a laser at 800 nm for 10 sec on the canine, both bucally and lingually, which had to be distalized after first premolar extraction. There was a highly significant positive difference in the rates of tooth movement on the experimental side compared with the control side. The mean increase in the rates of tooth movement at 3 months was 54% in the maxillary arch and 58% in the mandibular arch. Mean increase in the rate of tooth movement after canine retraction was 29% in the maxillary arch and 31% in the mandibular arch. There was a significant decrease in the pain score recorded, using a Visual Analog Scale.[18]Limpanichkul in their study did not found a significant result and concluded that the LLLT at the surface level in their study (25 J/cm2) was probably too low to express either stimulatory effect or inhibitory effect on the rate of orthodontic tooth movement.[19] The results of different studies vary depending on the frequency of application of laser, intensity of laser, and method of force application on the tooth.

CONCLUSION

In today's clinical practice there is an increased demand for shorter orthodontic treatment time. Also with an increased number of cases of adult orthodontics, we are often faced with a challenge of reducing the treatment time. The orthodontic treatment time can be reduced biologically by modifying the rate of orthodontic tooth movement. Procedures such as corticotomy and piezocision may have a RAP for around 4–6 months during which acceleration in the tooth movement might occur. As for MOP, the RAP lasts around 28 days after which the procedure has to be repeated. Further long term controlled trials are required to substantiate the available evidence so that these procedures could be used routinely with prescribed practice guidelines.

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