

REVIEW ARTICLE

Acceleration of Tooth Movement during Orthodontic Treatment

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ABSTRACT

“Orthodontic tooth movement” requires force application that causes resorption and apposition of bone on greater pressure and tension side respectively. “Conventional tooth movement” is biologically produced from the resorption and apposition of bone created by mechanical forces. “Accelerated tooth movement” includes the procedure where small-sized holes are made generally within the bone which surrounds the usual dentition. This in turn releases the cytokines which further attract the osteoclasts to enhance the effect of resorption of bone. Several multiple factors accelerate tooth movement. Out of them, relaxin has no effect on the movement of the tooth but at the same time, it can increase the mobility of the tooth. The surgical approach has the best predictable outcome but low application in acceleration because of its aggressiveness. Out of all the surgical approaches, the piezocision technique is the best. Hence the purpose of the study is to summarize all the clinical and experimental methods which are required to accelerate tooth movement during orthodontic treatment.

KEYWORDS: Accelerating tooth movement, bone remodelling, cytokines, relaxin, vitamin D

Received 04.06.2021

Revised 21.06.2021

Accepted 06.08.2021

How to cite this article:

R Mohanty, A Panigrahi, S Mohanty: Acceleration of Tooth Movement during Orthodontic Treatment. Adv. Biores. Vol 12 [5B] September 2021. 369-372

INTRODUCTION

The treatment given by the orthodontists includes the limited use of forces that are mechanically given to the tooth and healthy periodontium. These forces are normally generated by the activation of wires, springs, and elastics selected by the orthodontist and are usually consistent with an intended one and direction of movement of the tooth. The nature of tooth movement is determined by the mechanical stimulus on the cells of the periodontium. The deliberate selection of treatment mechanics specific to each individual's problems is required for effective, efficient and patient-centred treatment. Bone remodelling is a procedure in which both bone formation and bone resorption occurs in the tension and pressure site respectively. [1] By manipulating the amount of force application and the responses produced biologically from the periodontal ligament the movement of the tooth can be controlled to a greater extent [2]. Due to alterations of blood flow, the applied force on the teeth will have changes in the surrounding area of the PDL which in turn will secrete different inflammatory mediators. Due to these types of secretions bone remodelling occurs [3].

METHODS OF ACCELERATING TOOTH MOVEMENT

There are three different phases of movement of the tooth that includes: Initial phase followed by the lag phase and lastly the post lagone.

In the initial phase, tooth movement occurs rapidly due to force application.

Lag one is characterized by null movement.

Gradual movement is seen during the post lag phase [4].

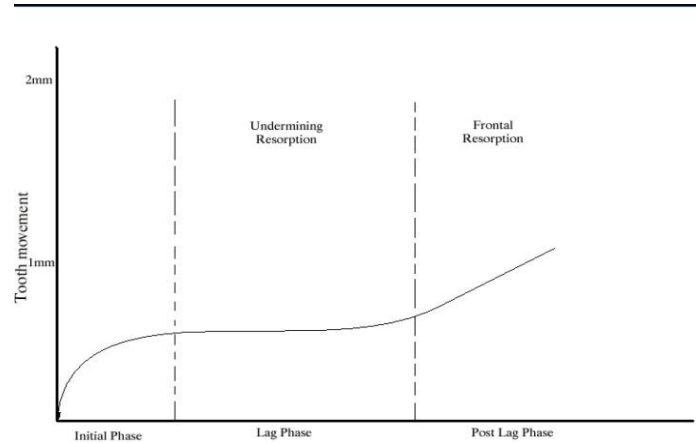


Figure 1. Three different phases of movement of the tooth

In the early phase, the leucocytes migrate out of the capillaries which in turn produces cytokines that enhance the release of growth factors mostly prostaglandin. The acute phase generally comes after the chronic phase. In this phase, a large number of molecules proliferate [5, 6].

NEED FOR ACCELERATING TOOTH MOVEMENT

Accelerated tooth movement as compared to conventional tooth movement reduces the treatment duration of the patient. It also minimizes the side effects associated with the treatment.

BIOLOGICAL APPROACH

This approach uses certain biological molecules which increases tooth movement. This is better studied through experiments performed on animals and humans.

CYTOKINES EFFECT ON TOOTH

A large quantity of cytokines like interleukins and tumour necrosis factor increases the remodelling of bone. (7) Interleukins act on osteoclasts through their receptors. It was also found that the mechanical stress that was released during orthodontic treatment caused the increased production of prostaglandin like PGE and Interleukin- 1 which was predominantly found on the tension side.

PROSTAGLANDIN EFFECT ON TOOTH

Under mechanical force i.e increase in cAMP and cGMP, prostaglandin is an important mediator of bone remodelling. Injections of PGE1 and PGE2 which are given into gingival tissues near the first molar increase tooth movement.

Disadvantages: severe pain after receiving injection and injections were to be repeated at weekly interval [8].

EFFECT OF VITAMIN D3 ON TOOTH MOVEMENT

Vitamin D and PTH increase the phosphorous and calcium amount in the body.

Receptors of vitamin D are present in both osteoblasts and osteoclasts. The movement of the tooth is stabilized by vitamin D stimulatory action on osteoblasts [9].

EFFECT OF PTH ON TOOTH MOVEMENT

PTH increases the movement of the tooth on rats. This was discovered by the repeated ingrain of PTH (1 to 10µg/100g of the weight of the body per day.) that was placed in the dorsocervical region and the molars were allowed to be moved 2to3 fold quicker in a mesial direction by spring that is coiled and is normally used in orthodontics [10].

RELAXIN EFFECT ON TOOTH

Relaxin belongs to the insulin family and is structurally related to insulin. It is produced during pregnancy. Relaxin expands the degradation rate of connective tissue which is fibrous and extracellular. Bone resorption is increased via an increase in TNF and IL-1 beta secretion. (11)

DEVICE ASSISTED TREATMENT

DIRECT ELECTRIC CURRENT STIMULATION:

It was given by Beeson *et al* and Davidovitch *et al*. Direct current used was 7volts and 15 microamperes. Anode was placed on the side which had greater pressure and cathode on the side which had greater tension. The amount of formation of bone and resorption at the electrically treated pressure side and tension side was higher. There was an increase in osteoblasts, PDL cells, osteoclasts [12].

MECHANISM: Direct electric current generated local response to increase AB turnover.

DISADVANTAGES: The device and battery that provided electric current were bulky.

ENZYMATIC MICRO BATTERY: It is used clinically (2009). It uses glucose as a fuel and enzymes as a catalyst. It is mostly placed on the gingiva near the alveolar bone and causes minimal tissue injury.

DISADVANTAGES: Has short lifetime, power density is poor.

ENDOGENOUS PIEZOELECTRIC STIMULATION:

Electric potentials can be created by applying force to a tooth resulting in bending of bone and generation of piezoelectric charges. The charges are created when stress is applied and released. Vibrations can be used to apply and release forces at a rapid rate. Accelerated vibratory system has high-frequency vibration (30 Hz) for 20min/day.

Mechanism: It stimulates cell proliferation and maturation to allow faster bone remodelling [13].

LOW-LEVEL LASER THERAPY:

Gallium Aluminium Arsenide irradiation, Wavelength used was 630 to 860nm; energy used was 4.5 to 6 J/cm². It is minimally invasive, simple and safe to apply.

MECHANISM: Increase in ATP induces the cubicle to experience remodelling because of an increase in consumption activity, rapid turnover of bone is contributed by the increase in vascular activity [14].

SURGICAL APPROACH:

There are various surgical approaches which contribute to a large extent in accelerating the movement of tooth. Few have been listed below:

CORTICOTOMY:

Local injury to the alveolar process reduces the resistance to tooth movement and generate RAP, indications are to resolve the crowd and shorten treatment time, accelerate canine retraction, enhance post orthodontic stability, molar distalization [15].

INTRASEPTAL ALVEOLAR SURGERY:

TECHNIQUE: Mucoperiosteal flap reflected and cortical holes are made in the alveolar bone from canine to the second premolar to pass 3to5mm from the apex. Then the holes were connected with tapering fissure. The first premolar is extracted and buccal bone is removed. Large osteotomes are used to mobilize the whole segment, and distraction is done after three days of surgery. The distractor is activated twice/day in the morning and evening for 0.8mm/day. It can also be used to bring ankylosed tooth in position. The disadvantage is aggressive and complicated [16].

PIEZOCISION TECHNIQUE:

This technique is one of the newest technique. Dibart first applied this technique. [17] This starts with an incision that is primarily placed on the buccal gingiva then followed by the incisions on the buccal cortex by a piezo surgical knife. (18)As reported by Hassan this process caused no harm to the periodontium. (19) Another benefit of this technique as reported by Keser²⁰ was, Invisalign can be combined with it which can modify the aesthetics of the patient and consume less time during treatment [20].

CLINICAL APPLICATIONS IN FUTURE:

The administration of exogenous biological molecules during orthodontic treatment has been intensively tested on animals to accelerate tooth movement. However, on humans, these trials are limited and must be given sometimes through injections which can cause pain and the patient may feel uncomfortable. Their adverse effect was untested. At the same time administration of certain molecules like PTH, cytokines, Vitamin D, RANKL/RANK/OPG system has shown promising results and they play a major role in tooth movement and remodelling process of bone. Relaxin on the other side do not help in acceleration but increases tooth mobility.

Laser therapy is very popular and the best among the physical approach.

The best method is the surgical one because it is mostly used in clinics and has good outputs. It has stable results and its predictions are known. But the major disadvantage of this method is that it is invasive, costly and aggressive.

Piezocision technique is the newest technique. It has the best outcome clinically and requires less incision.

CONCLUSION

Almost all the techniques mentioned above had drawbacks and uncertainties which made them be least used clinically. But there is a rapid increase of interest among the companies to increase the outputs of biology in orthodontic practice. All the rising approaches can lay great examples shortly.

Funding: None

Conflicts of Interests: Nil

Acknowledgements: None

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