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METHODS ACCELERATING TOOTH MOVEMENT: CHANGING THE OUTLOOK TOWARDS ORTHODONTICS

Dental Science

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ABSTRACT

Long drawn orthodontic treatment has been associated with increased risks of root resorption, periodontal disease, caries and changes or loss of patient compliance. Orthodontic treatment time has always been an area of rigorous research. Various attempts have been made to increase the rate of tooth movement while minimizing the associated side effects. It can be broadly classified into surgical and non-surgical approaches. Among the non-surgical methods various physical devices & pharmacological agents have come into existence. Effects of vitamin D, prostaglandin E1 and 2 Osteocalcin, parathyroid hormone, long-term or high dose corticosteroids on tooth movement has been studied and is still being researched. Physical devices like Acceledent, Orthopulse, Propel Device, Biolux & Aevo system have been tried to accelerate orthodontic tooth movement. Surgically derived regional accelerations of orthodontic treatment i.e. PAOO, dento-alveolar & periodontal distraction and its modifications have come into existence. Other surgical procedures have been modified from raising a flap to flapless techniques such as peizosicion, corticision and aleveocentesis which are becoming popular. Present article is an overview of all the methods being used to accelerate tooth movement.

KEYWORDS

PAOO, LLLT, LIPUS, Acceledent, Biolux, Aevo system

INTRODUCTION

The greatest challenge in any orthodontic treatment has been the time taken to complete the treatment. People have been researching and experimenting to hasten the process. The last decade has seen a lot of progress in this area which is the result of the increase in the research work done.[1] The result of the work done has increased the knowledge of the biology of the tooth movement at the molecular level and also the optimal response of alveolar bone to applied optimal force. This awareness has helped orthodontists discover and invent various ways and means to increase the rapidity of orthodontic tooth movement.

The results of Orthodontic Treatment on various factors like orthodontic factor, Oral hygiene, periodontal diseases, periodontal diseases, dental carries, pain, discomfort etc.[2]

Recent studies on the biological mechanism of tooth movement done at the cellular, molecular and tissue level, suggest that a mechanical force is not the only stimulus for inducing tooth movement, as believed earlier. Orthodontic force also does this by inducing a cellular response in the periodontal ligament which brings about bone resorption on the pressure side and bone deposition on the tension side. This is mediated by the induction of osteoclasts via the RANK -RANKL pathway and presence of various inflammatory mediators such as IL-1, IL-8, TNF-alpha etc. [3-13]

Since long, surgical methods have been employed to accelerate tooth movement. The movement is caused because when the bone is irritated by surgery it causes inflammation resulting in increased osteoclastogenesis which causes faster tooth movement. This is also known as Periodontal Accelerated Osteogenic Orthodontics (PAOO) or Regional Acceleratory Phenomenon (RAP). Being invasive, this has not gone too well with patients. With the help of piezosurgery, micro osteoperforations etc. there has been an influx of new surgical methods which achieve the same results as achieved by conventional methods. In addition to this mechanical or physical stimulation of the periodontal ligament has increased the speed of bone remodelling.[14-15]

Accelerated Orthodontic Tooth Treatment is the need of the hour. The methods for the same may be broadly divided under two categories:

1. Non – Surgical Approaches
2. Surgical Approaches

I NON-SURGICALAPPROACHES

Chemical Agents

Increasing the number of osteoclasts independent of orthodontic forces by inducing locally or systematically different chemical factors. The key is that the chemical should increase the rate of bone turnover so that it increases tooth movement.

Chemicals are used only after several animal and human trials. The commonly used chemicals are Prostaglandins, vitamin D3, cytokines and nicotine. Even though these are effective to a large extend, they do have their drawbacks. Their safety is an issue. They have a short half-life, which means multiple applications is required.[16]

Another example, vitamin D when injected in the periodontal ligament (PDL) increases the levels of LDH and CPK enzymes; Prostaglandin causes a generalized increase in the inflammatory state and root resorption. Hence, existence of a drug that can safely accelerate orthodontic tooth movement is still underway. Prostaglandins, RANKL, VEGF are emerging molecules which enhance tooth movement. Exogenous administration of prostaglandin induces bone resorption thereby increasing the rate of tooth movement. Prostaglandin has a direct action on osteoclasts in increasing their numbers and their capacity to form a ruffled border and effect bone resorption. Prostaglandins couple bone resorption and formation, increasing the bone cells turnover and thereby enhancing the orthodontic tooth movement. Despite these drawbacks, the progress is happening in the right direction.[17-26]

Mechanical Stimulation Methods

Other methods which are less invasive as compared to surgical methods. It is based on the fact that bone and periodontal ligament is a direct target of orthodontic forces; therefore by optimising mechanical stimulation, the rate of tooth movement can be increased. Various techniques used include direct electric current, pulsed electromagnetic field, static magnetic field, resonance vibration, and low level laser.

I) Low Level Laser Therapy (LLLT)

In 2004, Cruz et was the first to carry out a human study on the effect of low-intensity laser therapy on orthodontic tooth movement. They showed that the irradiated canines were retracted at a rate 34% greater than the control canines over 60 days. [27]

Saito and Shimizu found that low intensity laser therapy can accelerate bone regeneration in the midpalatal suture during rapid palatal expansion and stimulate the synthesis of collagen, which is major matrix protein in bone. [15]

The bio stimulatory effect on bone regeneration by a Laser is seen in

the midpalatal suture during rapid palatal expansion and also helps in bone regeneration after extraction or fracture. Bone remodelling and accelerate tooth movement is also a result of proliferation of osteoclast, osteoblast and fibroblasts induced by Laser.

Gauri Doshi Mehta et al also worked on the same in 2013. They 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 used a Ni-Ti closed coil spring delivering a constant force of 150 g from the first molar tube hook to the power arm of the canine bracket and also secured with a ligature tie to the bracket. The total energy density (dose) at each application was 8 J (2 × 40 s × 100 mW).

6 months later, periapical radiographs of the laser side (experimental) and the control side canines were examined, which showed no undesirable changes in the adjacent periodontal ligaments and alveolar bones. Positive vitality tests of the retracted canines were also reported.

Studies have also shown that Erbium laser reduces the pulpal temperature and can also be used to cut the bone with minimal temperature. Another high is ability to facilitate flapless corticotomy to speed up treatment time and eliminates the necessity of invasive flap surgery.[27]

To sum up, low level laser therapy helps increase tooth movement.

I) Vibration

The latest equipment available in the market today is Acceledent. It is used to reduce the time of orthodontic time and is believed to reduce the time by about 30%- 40%. It uses the technology of vibration. The activator of the device delivers the vibration impulses with a USB interface through which be connected to a computer to review the patient usage of the appliance, a mouthpiece that contacts the teeth. Since the device is portable, it can be worn for about 20 minutes per day. [28] However, as the system is newly introduced, further long-term research is required to prove its results.

ii) Direct Electric Current

One of the more successful techniques has been the direct electric current techniques. After testing it on animals, it was proved that electrical currents generated peizoelectrically or direct current and therefore enhanced the rate of tooth movement.

The drawback was that these could not be tested clinically because of the bulk of the devices and the source of electricity. Many attempts were made soon after to develop biocatalytic fuel cells to generate electricity by the use of enzymes.

According to Davidovitch, mechanical stress induced electrical potentials in bone and activated the cells that participate in the remodeling process. Also, the electrical stimulation in conjunction with mechanical force can increases the rate of tooth movement. Pulsed electromagnetic fields are produced by an integrated circuit embedded in a removable denture (0.5mt and 1Hz V8 hours per day overnight). [29-30]

iii) Phototherapy

A patent application for the use of phototherapy to speed tooth movement was filed in late 2010, and clinical trials now are being conducted. Phototherapy (Biolux) uses light within 800 to 850 nanometer wave length (just above the visible spectrum) that penetrates soft tissue and “infuses light energy directly into the bone tissue”. Experiments have shown that about 97% of the light energy is lost before it penetrates through the cheeks and alveolar bone to the interior of a recent premolar extraction site, but the remaining 3%is said to have enough energy to excite intracellular enzymes and increase cellular activity in the PDL and bone. This presumably would increase the rate of bone remodelling and tooth movement. Phototherapy in other applications has been shown to increase blood flow, and this also might affect the rate of tooth movement. An interesting aspect of the Biolux device is that it can be adjusted to apply light to only the anterior teeth, the whole arch, or only the posterior teeth, which certainly would potentially improve anchorage control if the light application does speed up tooth movement in the illuminated area. [31]

iv) Low Intensity Pulsed Ultrasound Therapy

Low intensity pulsed ultrasound (LIPUS) therapy has a history of over 20 years. This proven history, along with the orthodontic challenge, inspired the development of the Aevo System™, a home-use orthodontic therapy. The patented 'Aevo System™' is also the most advanced therapeutic LIPUS system in the world. It consists of our Check & Adjust clinic software, versatile electronics, oral ultrasound gel, and our intraoral transducer system. This battery powered safe, easy-to-use device is to allow for greater portability. It's also available in three models for customizable home treatment. [32-33]

SURGICAL APPROACHES

Frost in 1983 introduced the idea of Surgical Technique. He came up with the introduction of Regional Acceleratory Phenomena (RAP). . RAP is a local response to noxious stimulus, by which tissue forms faster than the normal regional regeneration process. This phenomenon causes healing to occur 2–10 times faster than normal physiologic healing by enhancing the various healing stages.

Surgical technique is an effective technique, especially for adults. It accelerates the tooth movement and reduces the time taken.

I) Corticotomy and PAOO (Periodontally accelerated osteogenic orthodontics)

These include corticotomy-facilitated tooth movement and PAOO. Although highly predictable, these procedures are very invasive and involve a lot of risk as well as postoperative complications. These procedures are based on the principle of regional acceleratory phenomenon (RAP) which is a part of healing event and is a localized osteoporosis state. The two main features of RAP include decreased regional bone density and accelerated bone turnover, which are believed to facilitate orthodontic tooth movement. By enhancing the various healing stages, corticotomy-facilitated tooth movement makes healing occur 2–10 times faster than normal physiologic healing. Corticotomy-facilitated tooth movement technique doubled the rate of orthodontic tooth movement. PAOO is a modified corticotomy facilitated orthodontic technique with the addition of alveolar augmentation which has an advantage of increasing the volume of alveolar bone and allows for correction of preexisting bony dehiscences and fenestrations. Potential advantages of the PAOO technique apart from reducing orthodontic treatment time from 1/3rd to 1/4th of traditional orthodontic treatment are that it also widens the scope of malocclusion treatment by enhancing the limits of tooth movement, decreases need for extractions, and enhances post orthodontic stability. It is useful for subtle enhancement of patient's profile by alveolar reshaping, less root resorption due to reduced resistance of bone, and for simultaneous rapid recovery of shallow unerupted teeth. [34-35]

ii) Corticision

Kole introduced Corticision. It is a surgical procedure, where the medullary bone is not cut, only the cortical bone is cut and perforated resulting in accelerated tooth movement because of reduction in resistance of the cortical bone. Another advantage is that the bone can be augmented, thus preventing periodontal defects. It ensures minimal changes in the periodontal attachment apparatus.

On the flip side, there are chances of infection or avascularnecrosis. Post-operative pain is prevalent.[36]

iii) Interseptal Alveolar Surgery

Interseptal alveolar surgery is also known as distraction osteogenesis. The concept of distraction osteogenesis came from the early studies by Ilizarov of limb lengthening in 1988. Furthermore, from surgical treatments of craniofacial skeletal dysplasia, this concept was later adapted in relation to the rapid tooth movement. The rapid canine distraction of PDL, involves surgically undermining the interseptal bone distal to the canine at the same time of extraction of the first premolars; thus, this will reduce the resistance on the pressure site. In this technique, the compact bone is replaced by the woven bone, and tooth movement is easier and quicker due to reduced resistance of the bone.

This is one of the methods that showed accelerated tooth movement with no evidence of significant root resorption, ankyloses or root fracture.[37-38]

iv) Piezocision

A minimally invasive technique was introduced by Kim et al and Dibart et al. as an alternative to induce surgical damage to the alveolar

bone without any flap surgery. This technique, also known as piezocision, involves the scalpel and mallet insertion into the gingiva and the incisions are placed using an ultrasonic tool (piezocision). These incisions or bone injuries are responsible for the initiation of a deciduous demineralization process called the regional acceleratory phenomenon (RAP). The transient osteopenia associated with this phenomenon causes rapid tooth movement because the teeth move in a pliable environment. Because of the induced RAP effect, a pliable environment is expected after piezocision, which can lead to maxillary constriction and/or cross-bites for posterior teeth.

This technique has its advantages on the periodontal, aesthetic and orthodontic aspects. Therefore it promises to be the technique of the future. [39-40]

v) Micro Osteoperforation

Micro osteoperforation in orthodontics is a process of creating small pinhole openings (or perforations) in the bone around the teeth to accelerate tooth movement during orthodontic treatment. It is an in-office procedure done with no down time after and can be used in conjunction with all orthodontic treatments. Teeth move through bone with the help of many cells, including cells that cause inflammation. By creating these perforations in the bone, a favourable inflammatory response is induced, utilizing your own biology to stimulate the bone around the teeth, resulting in faster tooth movement.

This is by a device called Propel, introduced by Propel Orthodontics. They had termed the process as Alveocentesis meaning, puncturing bone.

Patients did feel mild discomfort locally but this lasted for about a fortnight after which the pain disappeared. It reduces the treatment time by 62%. [41]

CONCLUSION

There is an increase in the awareness about oral health and having a perfect smile. A lot more number of people are opting for Orthodontic treatment. But the patients demand a quicker treatment plan for various reasons.

The current methods such as piezocision, microosteoperforations, lasers and vibration have reduced or eliminated the invasive nature of previous procedures to achieve the Regional Acceleratory Phenomenon. Also, they come with additional advantages such as reduced rates of relapse, reduced orthodontic pain and reduced root resorption.

Since a lot of patients want a reduction in the treatment time as well as make fewer trips to the Orthodontists, these methods are being well received. Accelerated orthodontics is a very new field, therefore not much research for long term results has happened in this area. Yet most researchers claim that the results would be long lasting.

One of the biggest disadvantages of accelerated orthodontics is the cost. This procedure will not be covered by most insurance companies, and it is the most expensive type of orthodontics you can choose.

With more awareness, more research is bound to happen which will definitely result in even better results and time reduction.

LIST OF ABBREVIATIONS

- Periodontal Accelerated Osteogenic Orthodontics (PAOO)
- Regional Acceleratory Phenomenon (RAP)
- Periodontal ligament (PDL)
- Osteoclast precursors express a cell-surface receptor known as RANK RANK stands for Receptor Activator of Nuclear factor-Kappa B. Osteoblasts express RANKL RANK Ligand on the extracellular surface of their plasma membrane (RANK-RANKL)
- Serum lactate dehydrogenase (LDH)
- Creatine phosphokinase (CPK)
- Vascular endothelial growth factor (VEGF)
- Low Level Laser Therapy (LLLT)
- Low intensity pulsed ultrasound (LIPUS)

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