Accelerated Osteogenic Orthodontics

B. Surender[1,*], P. Kiran Kumar [2], R. Naveen[3], T. Saritha[4]

[1]Post Graduate (MDS), [2-4]Reader, Dept. of Orthodontics and Dentofacial Orthopedics, [1-4]Mamata Dental College and Hospital, Giriprasad Nagar Khammam, Telangana, India

***Corresponding Author: B. Surender**
Email: surenderb506@gmail.com

Abstract
In patients seeking orthodontic treatment, the duration of the orthodontic treatment is the main concern. The prolonged duration of orthodontic treatment also concerns the orthodontists, resulting in the need for faster orthodontic treatment. As the orthodontic treatment depends on the response of tooth surrounding tissues, various ways are being sought to accelerate orthodontic treatment.

Keywords: Corticotomy, Osteotomy, Accelerated tooth movement, Piezocision, Direct electric current, Low level laser therapy, Prostaglandins, VitaminD3, Parathyroid hormone, Cytokines, RANKL, RANK, Osteoprotegerin (OPG), Regional acceleratory phenomenon, Accelerated Osteogenic Orthodontics (AOO).

Introduction
Apart from the challenges of restoring occlusion, esthetics and function, treatment duration is also a major challenege that has to be addressed which will be a motivating factor to patients to seek orthodontic treatment. Thus, researchers are searching methods to shorten the duration of tooth movement, because prolonged treatment duration causes inconvenience to the patients and predisposes to caries, gingival recession, inflammation of gingiva and root resorption.[1]

Three main methods are used to enhance the rate of tooth movement.[2]

1. Biological Approach.
2. Surgical Approach.
3. Physical Approach.

Biological approach
Many kinds of experiments have been performed exogenously on molecules like Prostaglandin E, Cytokines, Receptor activator of nuclear factor kappa B ligand (RANKL), and Macrophage colony-stimulating factor (MCSF) to enhance the rate of tooth movement in both humans as well as in animals.[3-5]

Cytokines
Cytokines which are the extracellular signaling proteins accelerate the tooth movement by altering the remodeling of bone and also the inflammatory process at the time of tooth movement. They facilitate bone and PDL cells differentiantion, activation, and apoptosis. Interleukins (IL-1, IL-2, IL-3, IL-6, IL-8) and TNF (Tumour Necrosis Factor) in high concentrations are known to be a major part for bone remodeling. However, the production of PGE and IL-1beta in periodontal ligament were increased due to mechanical stresses of orthodontic treatment.[5]

Macrophage colony stimulating factor (M-CSF) and RANKL (Receptor activator of nuclear factor-kB ligand) are the most important pro-inflammatory cytokines responsible for engaging, differentiation, exhilaration and survival of osteoclasts which are responsible for acceleration of tooth movement. RANKL binds to RANK receptors on osteoclasts leading to osteoclastogenesis thereby enhancing tooth movement. Root resorption in many patients is seen due to large amounts of RANKL production in compressed site.[6-8]

Osteoprotegerin (OPG) competes with RANKL for binding to osteoclasts resulting in the inhibition of osteoclastogenesis. During bone remodeling there is always a balance present between RANKL, RANK and OPG.[9,10]

Prostaglandin
Prostaglandins (PGs) are the important inflammatory mediators that play a key role in initiating bone resorption by enhancing the production of number of osteoclasts. Administration of PGE2 in human trials showed the rate of distal retraction to increase 1.6 times more than control side.[11,12]

Vitamin D3
1, 25 dihydroxycholecalciferol plays a major role on calcium hemostasis along with calcitonin and parathyroid hormone (PTH). It was observed that the number of osteoclasts on the pressure side, which was reinforced by vitamin-D was more than on the PGE2 side, indicating that vitamin-D plays a major role in bone turnover.[13]

Parathyroid hormone
PTH stimulates bone resorption, which results in an increase in the calcium concentration in the blood. Bone resorption occurs as a result of continuous elevation of PTH. Local administration of PTH is more useful than systemic administration, as locally administered PTH causes local bone resorption. PTH can also be used in an injectable gel form for slow release as local application of it increases the rate of tooth movement by 1.6 times when compared to daily injection of PTH dissolved in saline. This occurs in a dose dependent manner.[14]

Chemokines

These are heparin binding cytokines. They activate the osteoclast and increase bone resorption leading to acceleration of tooth movement.

Growth factor

Growth factors are substances that engage to specific receptors present on the surface of their target cells, stimulating cell proliferation, migration and differentiation. GF acts locally affecting the remodeling of the bone and also orthodontic tooth movement.

Thyroxin

It affects the calcium absorption process in the intestines. It enhances bone resorption causing an increase in the rate of tooth movement. It has an indirect effect on the bone turnover and osteoporosis induction.

Osteocalcin and Corticosteroids

Osteocalcin on local administration causes rapid tooth movement on amount of attraction of osteoclasts. They stimulate osteoporosis in the presence of cytokines.[15]

Effects of Relaxin on tooth movement

Relaxin causes widening of the pubic ligaments in women during parturition. It is also present in cranial sutures and PDL. Relaxin causes remodeling of soft tissue rather than the bone tissue. The rate of tooth movement is increased as the amount of collagen is increased on the tension side.

The effect of corticosteroids on tooth movement can depend upon the dosage and the time of administration related to the expression of cytokines. Corticosteroids may reduce the rate of tooth movement due to their anti-inflammtory effect.[15]

Advantages

1. Accelerate the rate of tooth movement.
2. Less tissue damage.
3. Patient acceptability.

Disadvantages

1. Injection of exogenous biological agents may have systemic effects.
2. Most of the chemical agents have shorter duration of action requiring multiple applications.
3. Post operative pain and swelling.
4. Results are not effective.

Surgical approach

As the treatment time is very important in adult patients, surgical approach is effectively used in them. Bone grafting, bone fracture and osteotomy cause an increase in the rate of bone remodeling.

Corticotomy

In corticotomy, only the outer cortical bone is altered or modified. The medullar bone is left intact and was first experimented in orthodontics by Kole.[16] Later this technique was further adopted by others, like Grenerson et al.[17] for treating open bites. In 2001, Wilcko et al[18] observed that the bony block movement postulated by Kole[16] was not responsible for the accelerated tooth movement. According to him, it was a bone remodeling process occurring at the site of surgery called as Regional Acceleratory Phenomenon (RAP). The technique was called as Accelerated Osteogenic Orthodontics (AOO). It was an invasive technique and the increased rate of tooth movement was seen in the initial 3-4 months.

Advantages

1. Accelerated tooth movement.
2. In regions with thin alveolar bone, bone can be augmented as a result of which periodontal defects can be prevented.
3. Orthodontic treatment duration is decreased.
4. Root resorption is known to be very less.
5. There was change in cephalometric positions of point A and point B.
6. There is an improvement in the structural integrity of periodontium.
7. Tooth movement occurs in 2 weeks which is much faster when compared with conventional orthodontics.
8. Lip posture is also improved in some cases by the addition of alveolar bone.
9. AOO procedure can be used to treat fenestrations over the root prominences.

    a. Duration of orthodontic treatment is reduced.
    b. Less likelihood of root resorption.
    c. Comparable tooth movements are accomplished in 2 weeks as compared to 6- to 8- week intervals of conventional orthodontics.[16]
    d. AOO procedure can be used to cover preexisting bony fenestrations over the root prominences.
    e. An increase in cephalometric point A and point B area.[17,18]
    f. In certain situations, the additional alveolar bone can also provide improved lip posture.
    g. An improvement in the structural integrity of the periodontiu

Disadvantages

1. The rate of morbidity is usually high.
2. Being an invasive procedure, it has its own risks similar to other surgeries.
3. The surrounding vital structures may be damaged.
4. There could be post-operative pain, swelling, infection and necrosis of tissues.
5. Expensive procedure.

Piezocision technique

The first person to use piezocision technique was Dibart[19] in which one degree incision is placed on the buccal gingiva followed by incision using peizosurgical knife to buccal cortex. It has better patient acceptance.

Jeorge et al in 2013, used a metal wire as a guide for the placement of incisions for corticotomy cuts. This procedure is known as MIRO technique (Minimally Invasive Rapid Orthodontic procedure).

Advantages
1. Minimally invasive than corticotomy.
2. Better patient acceptance.
3. Enhanced rate of tooth movement.

Disadvantages

Risk of damage to roots, if incisions and corticotomy are performed blindly.

Micro osteoperforations

On the buccal or lingual cortical plates, many small shallow perforations are made adjacent to the moving teeth. This results in increased inflammation, activation of osteoclasts and remodeling of bone and tooth movement.[20, 21]

Advantages
1. The rate of tooth movement increased more efficiently.
2. Less surgical complications, as the process is minimally invasive.
3. Can be repeated if necessary.
4. There is less discomfort and pain to the patient.

Disadvantages
1. Invasive.
2. Adjacent tissue damage.
3. Post operative pain and swelling.

Physical approach

Regardless of the approaches, surgical methods are invasive and hence necessitated the need for physical methods.

There is bone bending and bioelectrical potential caused by physical approaches such as the application of orthodontic forces. The concave sites have negative charge and they attract osteoclasts, conversely the convex sites attract osteoblasts.

Vibrations when applied for different durations per day also accelerate tooth movement.

Photo-bio modulation or low-level laser therapy (LLLT) is one of the best known approaches currently. Low level laser therapy (LLLT), photo bio modulation is becoming the most promoted procedures these days to accelerate tooth movement. Bone regeneration is stimulated, similar to that seen during rapid maxillary expansion (RME).[22,23] Laser light effects the remodeling of bone and movement of teeth by inducing osteoclast and fibroblast proliferation. Increase in the rate of tooth movement is because of the production of ATP and activation of cytochrome C. As there are no side effects on the periodontium at the time of remodeling of bone by low level laser therapy, it is considered highly advantageous when compared to other techniques.[22]

A group of investigators applied direct electrical current to the anode on pressure side and cathode on the tension side, which generated local response and remodeling of bone was accelerated. As the electrodes were placed very close to the tooth to be moved. Their studies were accepted and successful.[24]

Advantages
1. It is a non invasive approach.
2. Anti inflammatory effect by using LLLT.

Disadvantages
1. Inconsistent results.
2. Mechanism of action is not clear with LLLT.

Clinical application

In human trials use of exogenous biological molecules are in limited use because their administration is painful and discomforting to the patients. Their side effects are also not been tested for longer period of time. Administration of certain molecules such as cytokines, PTH, vitamin-D, RANK/ RANKL/OPG system yielded positive results. Because of variation in energies, time and experimental design, use of LLLT shows contradictory results despite of being a promising procedure.

Most of the experiments were performed for only a few weeks for the identification of side effects. The surgical approach, which is the most likely used approach gave stable results despite of being invasive, aggressive and expensive. Piezocision technique is one of the latest techniques, which is least invasive and has good clinical results in increasing the rate of tooth movement in the surgical approach.

Conclusion

Now a days, we have methods and resources of superior quality which not only enable us to provide quick but also comfortable orthodontic treatment to both children and adults. Although these techniques have certain drawbacks associated with them, they are a step closer to quicker orthodontic treatment making them close to orthodontics success.

Conflict of Interest: None.

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