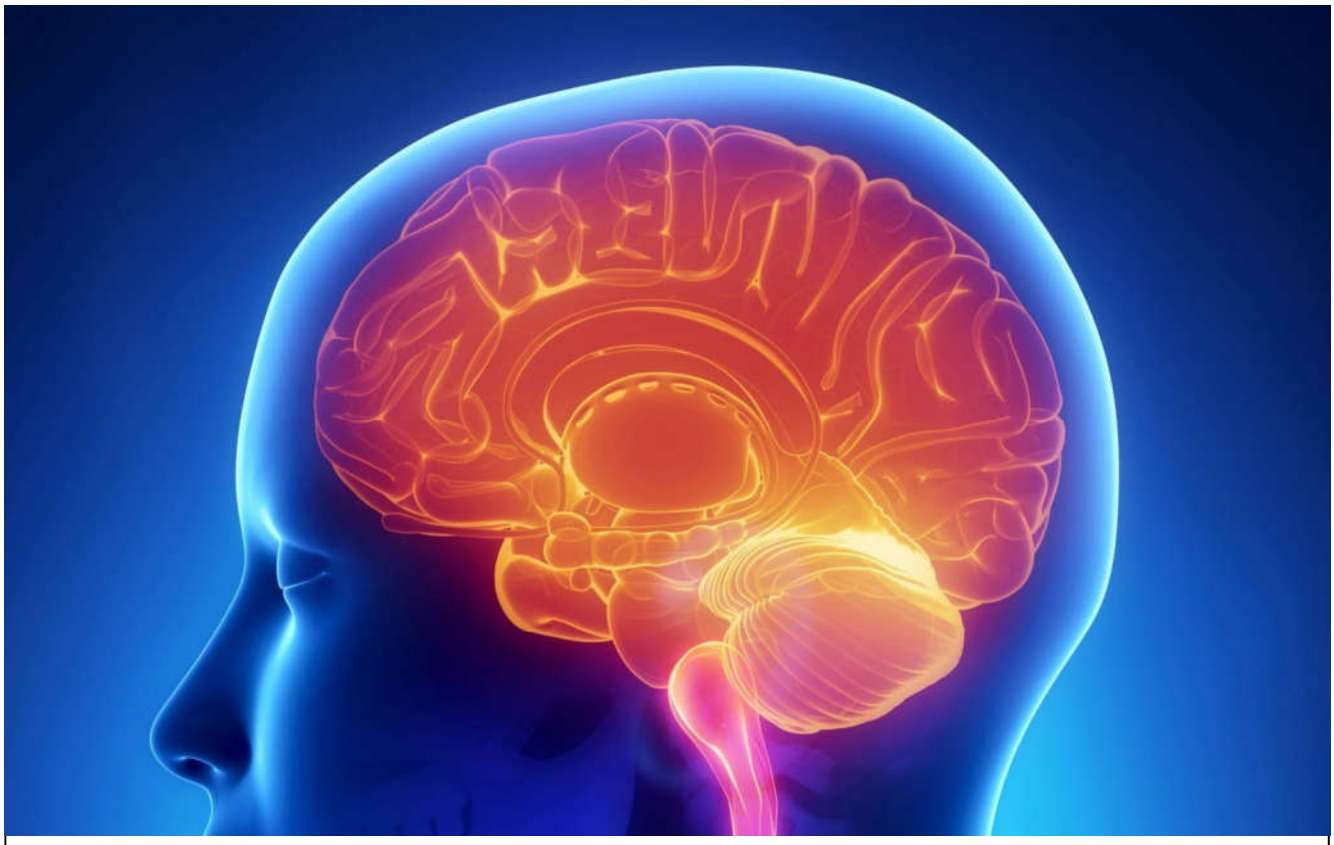

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Review Article

MODALITIES OF ACCELERATING ORTHODONTIC TOOTH MOVEMENT: A REVIEW

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ABSTRACT

Orthodontic practice aims at improving facial harmony, esthetic balance and functional aberrations. The duration of treatment plays a pivotal role as it dictates patient's cooperation and psychological assistance. Orthodontic treatment can range anywhere between 12-48 months. Longer treatment time poses disadvantages like high predisposition to caries, gingival recession and tooth resorption. The methods employed are mechanical / physical stimulation methods, surgical methods, lasers and magnets. It can be shortened by up to 70 % by employing different modalities. Thus, this article is indicative of the newest modalities to accelerate tooth movement. The reduction in treatment time helps in patient acceptability. This review also highlights on the cellular, molecular mechanisms that accelerate Orthodontic tooth movement. Clinically applicable methods need be employed in practice to provide proper directions for future studies and research. This paradigm shift would ultimately lead to faster case finishing allowing practices to grow with an increase in new starts each year.

INTRODUCTION

The speciality of Orthodontics has been propelled by various researches regarding the alveolar bone, it's processes, optimal force e.t.c. Optimal Orthodontic force induces a cellular response in the periodontal ligament bringing about bone remodeling. This pathway is via RANK-RANKL and various other inflammatory mediators like IL-1, IL-8 and TNF-ALPHA. The RANKL/RANK binding is crucial for the differentiation, function, and survival of osteoclasts.

On the other hand, osteoprotegerin (OPG), another osteoblastic cell-derived factor, interrupts the RANKL/RANK binding as a decoy receptor of RANKL, inhibiting osteoclastogenesis.[1]

Therefore, the RANKL/OPGratio expressed by osteoblastic cells and the RANK expression by osteoclast precursor cells largely determine the formation of functional osteoclasts and the activation of the initial step of bone remodeling.

Orthodontic tooth movement lasts for about 12-48 months. Patient's urge for shorter treatment times has led to the introduction of various methods that accelerate tooth movement.

METHODS

The following modalities for accelerating tooth movement are:

1. Drugs
2. Surgical methods
3. Device assisted methods
4. Miscellaneous

Drugs [10]

Parathyroid hormone is the major hormone regulating bone remodeling and calcium homeostasis. Chronic local injection of parathyroid hormone has been found to accelerate Orthodontic tooth movement by about 1.6- to 2-fold, and significantly increase osteoclast numbers.

1, 25 Dihydroxy vitamin D3 acts on bone cells to increase bone remodeling. Local injection of 1,25dihydroxy vitamin D3 accelerated orthodontic tooth movement by about 1.2- to 2.5-fold in animal studies. Histologically, it stimulates the formation of osteoclasts in a dose-dependent manner, synergizing with the mechanical force and causes significantly more alveolar bone resorption.

Prostaglandins are local autocrine /paracrine lipid inflammatory factors that also regulate bone remodeling.

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Several animal experiments have shown that local application of PGE1, PGE2, or analogs of PGE1, PGE2, or Thromboxane A2 increase the speed of Orthodontic tooth movement. Local submucosal injection of PGE1 in human patients are also successful in accelerating tooth movement by 1.6-fold. One concern of using PGs clinically is the pain reaction from patients, since PGs are potent pain inducers. Another concern is increased root resorption concomitant with accelerated tooth movement.

Alternatively, Orthodontic tooth movement is impaired by Non Steroidal Anti-Inflammatory drugs.

Surgical Methods

The four types of surgical damage to the alveolar bone include Osteotomy (complete cut through cortical and medullary bone), corticotomy (partial cut of cortical plate without penetrating medullary bone), ostectomy (removal of an amount of cortical and medullary bone) and corticotectomy (removal of an amount of cortex without medullary bone).

More vivivdly, it can be categorized as[3]:

- Distraction of the PDL aided by alveolar surgery undermining the interseptal bone
- Intraseptal alveolar surgery
- Rapid canine distalization by segmental alveolar distraction
- Rapid canine distalization by segmental alveolar distraction
- Rapid canine distalization by segmental alveolar distraction
- Rapid canine distalization by segmental alveolar distraction
- Corticotomy-assisted tooth movement
- Accelerated osteogenic orthodontics
- Corticotomy
- Piezocision technique
- Piezocision-assisted Invisalign treatment

History

It dates back into:

1892: L.C. Bryan & Cunningham: surgical technique for correction of malocclusion
1931: Bichlmayr: surgical technique for rapid correction of severe maxillary protrusion with orthodontic appliances
1950: Corticotomy with Osteotomy
1959: Heinrich Kole: block bony movement
1981: H.M. Frost: Regional Acceleratory Phenomenon
2001: Wilcko and co-workers: Accelerated Osteogenic Orthodontics transient localized demineralization remineralization phenomenon
2006: Park: Corticision technique
2007: Vercellotti and Pedesta: monocortical tooth dislocation technique with a piezoelectric knife
2009: Kim: corticocision technique without flap reflection

The major types are described below

Paoo Technique / Corticotomy Assisted Bone Augmentation Approach

It is a combination of a selective decortication facilitated Orthodontic technique and alveolar augmentation where teeth can be moved 2 to 3 times further in [1/3] to [1/4] the time required for traditional Orthodontic therapy.[4] It can be used to treat moderate to severe malocclusions in both adolescents and adults and can reduce the need for extractions. It involves 3 basic steps: selective alveolar corticotomy, particulate bone grafting and application of orthodontic forces.

The method of PAOO is patented by "Wilckodontics" based on the emerging concepts of Wilcko brothers.[5]

Indications

1. PAOO contributes to increased bone volume
2. Crossbites and tooth size-arch length discrepancies can be corrected
3. Crowding correction of 10-12 mm is possible
4. Conservative approach rather than orthognathic surgery (except for severe class III skeletal dysplasia)
5. Moderate to severe malocclusions like severe bimaxillary protrusion and cleft lip palate cases
6. Uprighting of tipped molars and intrusion of supra erupted molars
7. To treat impaction cases at a faster rate

Advantages of PAOO

- Decreased overall treatment time
- Increased bone support due to the addition of bone graft
- Reduced root resorption due to decreased resistance by cortical bone
- Increased limits for envelop of discrepancy
- Low relapse reported

Disadvantages of PAOO

- Mildly invasive surgical procedure, and like all surgeries, it has it's risks
- Post-surgical crestal bone loss and recession may occur
- Pain and swelling is expected

Piezocision

In 2009, Dr. Serge Dibart, his team from Boston University and SATELEC® collaborate to develop a reproducible, reliable and minimally invasive technique called Piezocision.[7]
It is the combination of:

- Micro-surgical incisions performed with SATELEC® Piezotome® powered ultrasonic Generators and
- Orthodontic tooth movement

This approach combines microincisions to the buccal gingivae that allow for the use of the piezoelectric knife to decorticate the alveolar bone to initiate the regional acceleratory phenomenon. Although it is minimally invasive, it also has the advantage of allowing for hard-tissue or soft-tissue grafting via selective tunneling to correct gingival recessions or bone deficiencies in patients.[6]

Indications

1. Patients should present a stable periodontium without periodontal disease
2. Patients should not be affected with a local or general bone disease or be subjected to a treatment such as immunosuppressive or biphosphonate
3. Class I or a mild class II associated with moderate to severe crowding

Advantages

1. Shorter to perform, minimally invasive and much less traumatic for the patient
2. When combined with bone grafting, Piezocision allows for an increase scope of treatment including allowing the correction of severe crowding without extraction
3. The postoperative discomfort after Piezocision is much lighter
4. Postoperative pain is usually minimal and well tolerated by patients

Disadvantages

1. Cortical incisions may present a risk of root damage particularly in areas of close root proximity
2. In addition, for patients presenting ethnic gingival pigmentation, soft tissue incisions can pose a cosmetic concern

Device assisted methods

This technique includes direct electric currents, pulsed electromagnetic field, static magnetic field, resonance vibration, and low level laser.

Cyclical force device effect on tooth movement

The vibration rate was 20 to 30 Hz and used for 20 min/day. One of the classic examples is the Acceledent device.[8,9]

Acceledent Device

One portion of the device is a mouthpiece similar to a sports mouthpiece, which the patient bites onto during use. The mouthpiece portion is connected to another piece that stays outside the mouth; this portion (activator) houses the components that provide the cyclic forces (vibration). The activator includes a battery, motor, rotating weights and microprocessor for storing usage data. The patient connects the mouthpiece to the activator and uses the device once daily for 20 minutes. The applied force from the device is at 0.2 N (20 grams). This low force is intended to be barely noticeable and not uncomfortable.

The device can be used with all Fixed Orthodontic appliances as well as clear resin aligners (Invisalign). The activator is placed in a docking station between uses to both recharge the activator and show compliance data.

Direct electric current effect on tooth movement[10]

This technique was tested only on animals by applying direct current to the anode at the pressure sites and cathode at the tension sites (by 7 V) thus, generating local responses and acceleration of bone remodeling.

Low level Laser Therapy

Photobiomodulation or lowlevel laser therapy (LLLT) is one of the most promising approaches today. Laser has a biostimulatory effect on bone regeneration, which has been shown in the midpalatal suture during rapid palatal expansion and also stimulates bone regeneration after bone fractures and extraction site. It has been found that laser light stimulates the proliferation of osteoclast, osteoblast, and fibroblasts, and thereby affects bone remodeling and accelerates tooth movement.[11]

The mechanism involved in the acceleration of tooth movement is by the production of ATP and activation of cytochrome that low-energy laser irradiation enhanced the velocity of tooth movement via RANK/RANKL and the macrophage colony-stimulating factor and its receptor expression.[12]

Miscellaneous

Microosteoperforations / alveocentesis

Teixeira *et al*., introduced MOPs on alveolar bone during Orthodontic tooth movement. It can stimulate the expression of inflammatory markers leading to increase in osteoclast activity and the rate of tooth movement.

In particular, by increasing the local levels of cytokine activity around a tooth, the rate of tooth movement during Orthodontic therapy can be increased. It creates predictable Orthodontic treatment results, improves finishing and reduces or eliminates refinements with clear aligner therapy. It can be completed chairside in minutes and does not require any advanced training. There is zero recovery time, and the patients are able to immediately return to their normal daily routine.

The procedure is indicated for approximately 80% of patients receiving Orthodontic treatment and can be used in conjunction with any treatment modality. There is less likelihood for decalcifications due to extended banding times leading to “white lesions.” Root blunting is reduced, as treatment duration is shortened. Shorter treatment time will allow patients to return to their normal oral hygiene routine and maintain clean teeth. Alveocentesis technique by using PROPEL System decreases orthodontic treatment time by 50-60%.[13]

PROPEL System was designed and developed specifically to maximize the alveolar bone remodeling effect while providing a safe and simple device that can be used by any clinician. The treatment edge of the PROPEL device is made of hardened stainless steel and designed to protect the integrity of the bone. PROPEL maintains its sharpness when treating an entire dentition because of an organic electropolishing process. PROPEL profoundly diminishes the effect on soft tissue, in contrast to other currently available rotary instruments.[14]

USES

1. Molar uprighting
2. Lower anterior crowding
3. Canine impactions
4. Forced eruption
5. Difficult aligner movements
6. Space closing
7. Rotations
8. Intrusion
9. Correction of Curve of Spee

10. Pre-surgical orthodontics
11. Pre-esthetic (prosthetic) orthodontics
12. Avoid surgical intervention

Monocortical Tooth Dislocation and Ligament Distraction Technique

Vercellotti and Podesta introduced this technique where two different dental movements that work separately but simultaneously on opposite root surfaces take place. Vertical and horizontal microsurgical corticotomies are performed around each root surface of the tooth in the direction of desired root movement with a piezo surgical microsaw. Applied strong biomechanical forces produce rapid distraction of ligament fibers leading to faster tooth movement.

CONCLUSION

Since time immemorial, Orthodontic patients have been seeking for shorter treatment times, and today, we do have methods that can fasten Orthodontic tooth movement safely. These methods come with additional advantages such as reduced rates of relapse, reduced Orthodontic pain and reduced root resorption.

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