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EVALUATION OF DIFFERENT FORMS OF ACCELERATED ORTHODONTIC PROCEDURES – A REVIEW

Orthodontology

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ABSTRACT

The technological advances has forever played a significant role in the development and gradual evolution of finer and relatively more efficient orthodontic appliances . Irrespective of the appliance used, the major issue common for all fixed orthodontic procedures has been the long treatment duration. This article aims to discuss both the surgical and non-surgical techniques. The latter includes therapeutic, irradiational, physical agents intended for the same. The surgical methods discussed here include Corticotomy, peizocision, micro osteoperforation. The physical agents include low level laser therapy, application of cyclical forces and so on. The therapeutic intervention encompasses two types of drugs, the promoter drugs and the suppressor agents. This article provides a brief review of the studies conducted in regard to the various techniques of accelerated teeth movements providing a comparative analysis on the weightage of the advantages and disadvantages of the techniques mentioned.

KEYWORDS

Therapeutic, Irradiational, Physical agents, Corticotomy, Peizocision, Micro osteoperforation

INTRODUCTION

For over a century the field of orthodontics has seen a drastic evolution right from the first fixed orthodontic appliance by Sir Pierre Fauchard1 to one of the most recent envisages in the form of aligners[2].

Inspite of the advances, the main challenge of lengthy treatment durations in fixed orthodontics has remained a matter of unanimous concern, especially when it comes to patients of this century, let alone the clinicians. Alkebsi et al (2018) in his study found that the average treatment duration of fixed orthodontic treatment ranges from 20 to 24 months[3].

Recent studies affirmed that mechanical stimuli are the most essential factors for orthodontic tooth movement. The term regional acceleratory phenomenon (RAP) was suggested by Frost and refers to the situation wherein an injury to bone results in the acceleration of all processes involved in healing, together with modeling, remodeling, cell turnover, metabolism, and inflammation[4].

Techniques used for accelerated tooth movement

Factors limiting the rate of tooth movement include bone turnover rate, bone density, and the extent of hyalinization of the periodontal ligament (PDL). Surgical modalities have been used to modulate these biological processes. These modalities take advantage of the regional acceleratory phenomenon (RAP), in which a noxious stimulus to the bone can accelerate bone turnover and reduce regional bone density, leading to a temporary osteopenia.

1.1 Surgical Methods.

The surgical methods include techniques such as Osteotomy, Corticotomy, Corticision, Piezocision & Micro-Osteoperforations

1.2 Device assisted therapy.

One more concept for accelerating tooth movement is by using device-assisted therapy. This includes cyclic forces, low level laser therapy.

1.3 Drugs.

The drugs used in orthodontics can be broadly categorized into two major groups, promoter drugs and suppressor agents. Promoter drugs are agents that act with the secondary and primary inflammatory mediators and enhance the tooth movement[5].

What is RAP or PAOO?[6]

- Regional Acceleratory Phenomena (RAP) is a local response to a noxious stimulus, which describes a process by which tissue proliferates quicker than the normal regional regeneration process. By augmenting the various healing stages, this phenomenon makes healing occur upto ten times faster than normal physiologic healing (Frost, 1983)[7]
- Many studies have reported an upsurge in the activity of inflammatory markers such as chemokines and cytokines in response to orthodontic forces. Chemokines play an essential role in the recruitment of osteoclast precursor cells, and cytokines, directly or indirectly, through the prostaglandin E2 pathway and the RANK/RANKL pathway, leading to the differentiation of osteoclasts precursors cells into mature osteoclasts. Therefore, it is rational to assume that increasing the expression of these factors, by surgically irritating the bone should accelerate tooth movement[8-11].
- A histological study confirmed that selective alveolar decortication induced elevated turnover of alveolar spongiosa (Sebaoun et al 2008). Surgery results in a substantial increase in alveolar demineralization, a transient and reversible condition. This will result in osteopenia. The osteopenia enables rapid tooth movement because teeth are supported by and moved through trabecular bone. As long as tooth movement continues, there is prolongation of RAP. When RAP dissipates, the osteopenia disappears and the radiographic image of normal spongiosa reappears. Then when orthodontic tooth movement is completed, an environment is created that favors alveolar re-mineralization
- Simply put, when bone is surgically irritated, a wound is created. This wound initiates a regional inflammatory response. Due to the presence of the inflammatory markers, osteoclasts migrate to the area and cause bone resorption. This effect, however, is temporary, and lasts for about 4 months[12], and the procedure needs to be repeated, in case faster tooth movement is still required.

The various surgical methods available are:

1.Corticotomy

The conventional corticotomy procedure includes elevation of full thickness mucoperiosteal flaps, followed by placing the corticotomy

cuts using either micromotor under irrigation, or piezosurgical instruments. This can be followed by placement of a graft material, wherever required, to augment thickness of bone[13].

Advantages

a. It has been proven successfully by many authors, to accelerate tooth movement.
b. Bone can be augmented, thereby preventing periodontal defects, which might arise, as a result of thin alveolar bone.

Disadvantages [14]

a. High morbidity.
b. Invasive procedure.
c. Chances of damage to adjacent crucial structures.
d. Post-operative ache, swelling, chances of infection, avascular necrosis.
e. Low patient compliance

2.Piezocision

To reduce the morbidity associated with conventional corticotomy, Dibart et al in 2009, introduced a flapless method of corticotomy, using piezosurgery[14].

In this technique, the surgery was performed 7 days after placement of orthodontic appliance, under local anaesthesia. Gingival vertical incisions, were made below the interdental papilla,buccally, as far as viable, in the attached gingiva with a No.15 scalpel. Full thickness incisions were given. Following this, corticotomy cuts were placed to a depth of 3 mm through the previously made incisions. At the areas requiring bone augmentation, tunnelling is executed using an elevator inserted between the incisions, to create enough space for graft material. No suturing is required, except for the areas, where the graft material needs to be stabilized. Patient is prescribed with an antibiotic and mouthwash.

Advantages

a. Reduced invasiveness.
b. Improved patient compliance

Disadvantages

a. Risk of root damage, as incisions and corticotomies are carried out blindly.

To reduce the risk of root damage, however, Jorge et al in 2013,[15] suggested a method, called MIRO (Minimally Invasive Rapid Orthodontic procedure) by using metal wire as a guide to placement of the incisions, and subsequently the corticotomy cuts. He placed metal guides in between each tooth, perpendicular to the principle arch wire, ensuring that the metal guides did not project over the tooth roots using radiographs, after which, incisions and piezoelectric corticotomy was done using the pins as a guide.

3.Micro-Osteoperforations (MOP)

Propel Orthodontics introduced Propel, a device designed to further ameliorate the invasive nature of surgical irritation of bone. By a process called alveocentesis, meaning penetrating bone[16].

It is a sterile disposable device with an adjustable depth dial and marking arrow on the driver body. The adjustable depth dial can be marked to 0 mm, 3 mm, 5 mm, and 7 mm of tip depth, depending on the area of operation.

Mani Alikhani et al (2013)[16], carried out a single blinded study to investigate this procedure on humans. They used a Ni-Ti closed coil spring, delivering a constant force of 100 g for retraction of the maxillary canine after first premolar extraction. The spring was attached to a Temporary Anchorage Device distal to the second premolar, and attached to the canine using a power arm through the vertical slot of the canine bracket. Cytokine levels from Gingival Crevicular Fluid were measured using a custom protein array for the following cytokines: CCL2 (MCP1), CCL-3, CCL-5(RANTES), IL-8 (CXCL8), IL-1a, IL-1b, IL-6, and TNF-a.

MOPs significantly increased cytokine and chemokine levels known to recruit osteoclast precursor cells and stimulate osteoclast differentiation.

MOPs amplified the rate of canine retraction upto 3 times. Patients reported only mild discomfort locally at the spot of the MOPs.

- MOPs proved to be an effective, comfortable, and safe procedure
- MOPs could decrease orthodontic treatment time by 62%.

III. Physical/Mechanical Stimulation

Irrespective of the Surgical method, these are still invasive to certain extent, therefore have their related complications. Subsequently, non-invasive methods have gained popularity, which include lasers, vibration, direct electric current etc.

Laser

Saito and Shimizu determined that low intensity laser therapy can boost up bone regeneration in the midpalatal suture during rapid palatal expansion with stimulation of the synthesis of collagen in bone. Histochemical studies showed an increase in the osteoblastic and osteoclastic activity after low-level laser therapy. The mechanism involved was the production of ATP and activation of cytochrome C and this method enhanced the velocity of tooth movement via RANK/RANKL (Receptor activated Nuclear Factor Kappa β/ Receptor activated Nuclear Factor Kappa β Ligand) and the macrophage colony-stimulating factor and its receptor expression[17].

In 2004, Cruz et al showed that the low level laser treated canines were retracted at a 34% greater rate than the control canines over 2 months[18].

Gauri Doshi Mehta et al in 2013,[18] in a split mouth design, used a semiconductor diode emitting infrared 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 providing a constant force of 150 g from the first molar tube hook to the power arm of the canine bracket securing it with a ligature tie to the bracket.

After 6 months, the laser and non-laser treated were studied and their periapical radiographs showed no undesirable changes in the adjacent periodontium. Canines were vital.

The average escalation in the rates of tooth movement at 3 months was 54% in the maxillary arch and 58% in the mandibular arch. Average increase in the rate of tooth movement after canine retraction was 29% in the maxillary arch and 31% in the mandibular arch. The Visual Analog Scale showed a significant reduction in the pain score.A semiconductor with a wavelength of 800 nm with 10 seconds exposure time was used since according to the study of Bradley et al, optimum bio-stimulatory effects on bone metabolism was shown about this dosage[18].

According to Limpanichkul et al in 2006, however, low level laser had no additive effect on orthodontic tooth movement, which may be due to a relatively higher energy density they used18. Numerous other studies on low level laser therapy, have demonstrated accelerated orthodontic tooth movement of upto 30-60%.

The difference in the results amongst the studies seem to arise from disparities in the frequency of application of laser, intensity of laser, and method of force application on the tooth.

Vibration

Nishimura et al in 2008,[19]used a Ni-Ti expansion spring on the permanent first molar of rats, applying a vibration of 60 Hz, 1 m/s2 . They found that the vibration treated rats showed enhanced orthodontic tooth movement. In the sectioned samples, they showed increased RANKL expression in the fibroblasts and osteoclasts of the periodontal ligament of the rats.

Liu et al in 2009 used an omega shaped Ni-Ti expander to deliver a force of 20 g on the first permanent molar. Mechanical vibration (4 Hz for 20 min/day) was applied perpendicular to the occlusal surface of the tooth seven times, at 3 days intervals. These teeth showed 40% more tooth movement[20].

Off late, a chargeable and portable device, Acceledent ,is designed to deliver the vibratory impulses with a USB interface that is connected to a computer to review the patient compliance with the appliance. It has to be worn for 20 minutes a day. This device is demonstrated to lessen the treatment time by 30-40%.

Comparative evaluation between different methods discussed above:

Gibreal et al took about 60% less treatment time by flapless

piezocision-assisted corticotomies in severely crowded lower anterior teeth as compared to the conventional therapy[21].

Microosteoperforation is technique sensitive as well as case sensitive. But Space closure through canine distalization with this technique is a less invasive as well an economical option for accelerated orthodontics. It attenuates the risks in comparison with other techniques such as corticotomies. Although, it is essential to consider that bone density differs in patients[22].

Low-level laser therapy, or LLLT when used with the parameters on the left, is an effective method for accelerating orthodontic tooth movement in crowding cases.

Laser was given at the roots of maxillary anteriors. laser tip was directed perpendicular to the root in contact of the mucosa .Each root was divided into 2 parts: cervical and apical .Laser tip was pointed both buccally and palatally thereby resulting in 4 points of laser application for each tooth[23].

Piezosurgery using low frequency ultrasonic waves (24.7-29.5 kHz), is programmed in accordance with the density of the bone and works only on mineralized hard tissue, not on soft tissue. This technique significantly reduces the risk of iatrogenic soft tissue damage .Henceforth, there was no need of raising a mucoperiosteal flap. But the disadvantage is that it is characterized by a relatively low cutting speed and subsequently with longer surgical time[24].

While the patient treated with corticotomy should obligatorily have a healthy periodontium, peizocision is indicated in adults with compromised gingival health. The flapless piezosurgical cortical micro-incisions technique guided by 3D-printed CAD-CAM , not only does not interfere with the marginal gingiva and is markedly less traumatic to periodontal tissues but also do not require any hard or soft tissue grafting. The use of ultrasonic techniques has advantages over other conventional instruments, including: A highly precise cut geometry without the needing overtly higher force; an proficient bone ablation, insignificant risk of accidental soft tissue damage therefore a diminuted risk of nerve damage[24,28,29].

However the significant disadvantage of this method is overheating, since the surgical template may hinder optimum irrigation of the piezoelectric cutting insert[30]. To counter this, it is essential to reduce the pressure on the piezoelectric cutting insert, frequently removing the micro-saw from the surgical guide to allow proper drainage of the bone fragments and cooling.

In a systematic review of Laser therapy, Sonesson et al (2017) concluded that all studies favouring this technique are inconsistent and further research need to be done in this field to validate the efficiency of Laser therapy for accelerating orthodontic tooth movement[25].

Pavlin et al (2015) directed a study to assess if a definite type of vibration, in addition to the fixed orthodontic treatment, increases the rate of tooth movementand concluded that a cyclic loading (vibration) of 0.25 N (25 grams) at the frequency of 30 Hz, as an aide to treatment with a fixed orthodontic appliance, significantly escalates the rate of orthodontic tooth movement[26].

In comparison to the different modalities which accelerate orthodontic tooth movement, including low-level laser therapy, pulsed electromagnetic fields, electrical currents, distraction osteogenesis, and mechanical vibration, only corticotomy has shown consistent results in accelerating the orthodontic tooth movement[27].

CONCLUSION

Owing to the constant demand of the orthodontic patients for lessened treatment time, further researches and meta analysis must be conducted for comparative assessment of the techniques discussed above , possibly with blinded study taking care of the confounding factors that come to play. Hence, validating an efficient method for the same.

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