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Micro-Osteoperforation in Accelerated Tooth Movement

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Abstract: ***The duration of treatment is one of the major drawbacks in orthodontics. Accelerating Orthodontic tooth movement (OTM) and reducing the length of orthodontic treatment may help to reduce not only discomfort but also possible dental and periodontal complications in patients. Micro-osteoperforation (MOP) is a minimally invasive procedure which activates pro inflammatory mediators, thus stimulating the inflammatory response. This eventually increases the rate of alveolar bone remodeling as a result accelerates the rate of tooth movement under controlled orthodontic forces.***

Keywords: Accelerated tooth movement, Micro-osteoperforation (MOP), Clinical Implications

1.Introduction

Orthodontic tooth movement occurs under mechanical forces leading to remodelling changes in dental and paradental tissues. This force creates a response in cellular component of periodontal ligament that leads to resorption of bone on the pressure side and apposition of bone on the tension side [1] [2]. This happens via induction of osteoclasts via the RANK-RANKL pathway and presence of various inflammatory mediators such as IL-1, IL-8, and TNF-alpha etc [3] [4] [5] [6]. The activation of osteoblasts and osteoclasts results in remodelling of supporting structures to influence orthodontic tooth movement [7]. Application of orthodontic force leads to alteration of blood flow around the surrounding tissue, which reduces the oxygen level at the pressure side [8]. This event leads to release of different inflammatory mediators like colony stimulating factors, cytokines, growth factors, arachidonic acid metabolites and neurotransmitters as a result of which remodelling of bone occurs [2] [7].

One of the primary concerns of the patient seeking orthodontic treatment is the duration of the treatment. In general, the duration of fixed orthodontic treatment is about 2-3 years. Prolonged duration of treatment poses risk of caries, external root resorption, gingival recession and decreased patient compliance [8]. Thus, there has been increased search for techniques that accelerates the orthodontic tooth movement (OTM).

Various methods of accelerating orthodontic tooth movement can be broadly categorised as [9]:

I. Surgical methods

a) Corticotomy
b) Periodontally Accelerated Osteogenic Orthodontics (PAOO)
c) Piezocision
d) Micro-osteoperforation
e) Interseptal alveolar surgery
f) Corticision
g) Sugery first approach

II. Physical/Mechanical methods

a) Low level laser therapy
b) Cyclic/ Resonance Vibration
c) Electric current
d) Electromagnetic field
e) LED device: Biolux
f) Therapeutic Ultrasound: Aevo system
g) Self ligating brackets

III. Drugs

a) Prostaglandin
b) Vitamin D3
c) Parathyroid hormone
d) Relaxin

2.Micro-Osteoperforation

Also known as alveocentesis, it is the least invasive procedure in which micro-trauma is induced to the alveolar bone thus producing Regional Acceleratory Phenomenon (RAP), which in turn increases the rate of orthodontic tooth movement [10]. Shortening orthodontic treatment time offers significant value to clinicians and patients alike. Less time in fixed appliances reduces the risk for external apical root resorption [11] and definer-libation/caries [12]; patient burn-out is less likely; young

patients will miss less school; parents or older patients will miss less work.

It is the process to accelerate the bone remodelling by increasing the local levels of cytokine activity around a tooth. The rate of tooth movement increase due to cytokine activity has been well documented to increase bone remodelling [13].

When micro-osteoperforations are created in the alveolar bone, the cytokine cascade is activated, resulting in a pronounced increase in osteoclast activity [14] [15]. The picture is shown in Figure.1, when orthodontic force F is applied to the tooth, inflammation occurs which means to have the irritation or swelling. Due to this the cytokines activity increases along either side of the tooth, the osteoblast or osteoclasts process takes place. The osteoblasts process means to destroy the bone cell and along the other side osteoclast process occurs which means to produce new bone cell. This procedure is of bone remodelling is called Micro Osteoperforation. This helps the teeth to go quicker and more easily through the processed field [15] [16].

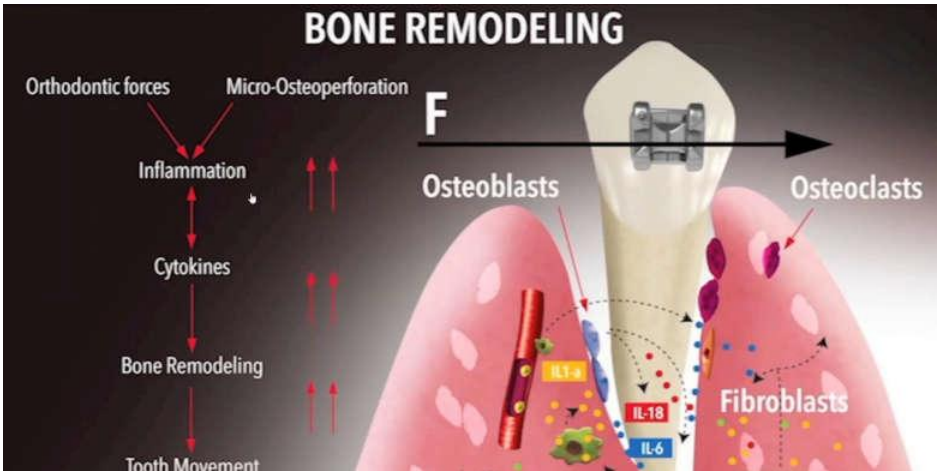

Figure.1 Cytokine Cascade [16]

The performing of micro-osteoperforations (MOPs) on alveolar bone during orthodontic tooth movement can induce the expression of inflammatory markers which leads to increase in osteoclast activity and rate of tooth movement [17].

The procedure can be performed with the help of PROPEL device introduced by Propel Orthodontics. It works by activating the cytokine cascade which in turn, results in marked increases in osteoclast activity and in turn the rate of tooth movement. This process is called as Alveocentsis [14]. Alveocentesis literally translates to puncturing bone [18].

The foremost part of the device, which is like an orthodontic stainless steel screw is patented, allowing perforation of alveolar bone traumatically over keratinized gingiva and moving mucosa. It is a device, which enables tissue remodelling and micro-osteoperforations between tooth roots over both stable and moving tissue of 1.5 mm diameter and 3, 5, and 7 mm depth without flap surgery in order to accelerate tooth movement. The device was also reported not to cause soft tissue damage while enabling remodelling process [14].

MOPs are placed in attached gingiva or upto 1mm apical to mucogingival junction. To achieve increased recruitment of osteoclasts (catabolic effect), deep perforations of 5-7 mm are required, whereas if increased recruitment of osteoblasts is required (Anabolic effect) then shallow perforations of 1 mm, spread over a large area is required. To enhance the rate of tooth movement, reactivation of the orthodontic appliance is done after 2 weeks [19].

3.Clinical Applications

Application of MOPs during leveling and aligning stages should be postponed until adequate space has been created. While MOPs can increase the number of osteoclasts, it will not change the side effects of the biomechanics plan and therefore similar to classic mechanics, the teeth without adequate space will not be able to engage in the main arch wire. MOPs can facilitate one of the most difficult movements to accomplish in orthodontics; root movement. By activating osteoclasts and decreasing the bone density, application of similar bodily movement mechanics can produce faster tooth movement and less stress on anchor teeth, since movement occurs in less time. For these reasons, MOPs are an excellent adjunct technique during protraction/retraction of a single tooth or group of teeth [20].

MOPs between the roots of teeth decreases the bone density while the bone density around anchor teeth remains unchanged. This procedure is especially useful when a tooth is moved into an edentulous space where alveolar bone is dense with a narrow ridge. MOPs can significantly decrease the bone density and allow faster and safer tooth movement while enhancing alveolar bone remodeling in that area. MOPs should also be considered during segmental intrusion, during which there is a possibility of root resorption due to high stress area around the root apex. While keeping the force light, MOPs

application around the apex prevents the prolonged cell-free zone that can cause root resorption. Clinicians should take into consideration that since the increase in cytokine activity decreases after 2 months of MOPs application, repeating the procedure every other month is recommended. And if TADs are being used to increase anchorage, application of MOPs adjacent to the location of the TADs should be avoided since decreased bone density around the TADs will likely decrease their stability [20].

Pain and external apical root resorption

The 2 main concerns about MOPs are pain and root resorption. MOPs are done under infiltration of local anesthetic. Patients who received MOPs did not demonstrate additional pain or discomfort when compared with patients who received only orthodontic treatment and did not require additional pain medications or additional care other than regular oral hygiene. External apical root resorption (EARR) is not increased following MOPs treatment. One main reason for EARR is high stress that produces a cell-free zone when a tooth is pushed towards dense bone [20]. In these areas, osteoclasts are recruited from the surrounding PDL and endosteal surfaces. The prolonged presence of osteoclasts, rather than the number of osteoclasts, causes EARR. While MOPs significantly increased the number of osteoclasts, these osteoclasts are on the adjacent endosteal bone surface not in the PDL [20].

Moreover, since MOPs decreases the density of the adjacent alveolar bone, the cell-free zone is smaller and cleared faster, which would prevent prolonged osteoclast activity adjacent to tooth roots. Thus, EARR risk decreases significantly in MOPs treatment, even during tooth movement over long distances [20].

Advantages of micro-osteoperforations over other surgical techniques

MOPs procedure is minimally invasive and flapless, allowing orthodontists to deliver care in their offices. Shortening orthodontic treatment time offers significant value to clinicians and patients alike. Less time in fixed appliances reduces the risk for external apical root resorption [11] and demineralization/caries [12]. It has zero recovery time, yields very little discomfort to the patient so the patients are able to return to their normal daily routine immediately and increases the rate of canine retraction by 2.3-fold [21].

Disadvantages of micro-osteoperforation

The increase in cytokine activity due to micro osteoperforation decreases after a period of two months. Therefore the procedure has to be repeated in every one or two months [22]. The MOP device is expensive which increases the cost of the treatment [23].

4.Conclusion

MOPs offers a practical, minimally invasive and safe procedure that can be repeated as needed to maximize the biological response to orthodontic forces and thus reducing the treatment time for orthodontics. It can be used in routine orthodontics at different stages of treatment, facilitating alignment and root movement, reducing the possibility of root resorption, stimulating bone remodeling in areas of deficient alveolar bone, and reducing the stress on anchor units.

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