

Review on Acceleration of Tooth Movement from Various Modern Approaches

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ABSTRACT

The duration of orthodontic treatment is the primary concern of most patients. Unfortunately, long orthodontic treatment time 12-48 months poses several disadvantages like higher predisposition to dental caries, gingival recession and root resorption. Therefore this increases the demand to find the best method to increase rate of tooth movement with the least possible disadvantages. By enhancing the body's response to these forces, tooth movement can be accelerated. Many approaches are available to accelerate tooth movement, such as biological approaches, surgical methods (corticotomy, piezosurgery etc), These approaches have been successfully proven to reduce treatment times by up to 70%. Hence, this article aims to review the latest approaches to accelerate orthodontic tooth movement.

Keywords: Accelerated orthodontic tooth movement, Corticotomy, Lasers, Piezosurgery

INTRODUCTION

Orthodontics has been developing greatly in achieving the desired results both clinically and technically. This is especially so by using new technologies, like stimulation software that can assist in treatment planning and translational products. In addition, continuous modification of wires and brackets as a result of the biomechanical efficiencies in orthodontics has greatly improved. However, these biomechanical systems may have reached their limit and there is a need to develop new methods to accelerate teeth movement. Today, it is still very challenging to reduce the duration of orthodontic treatments. It is one of the common deterrents that faces orthodontist and causes irritation among adults plus increasing risks of caries, gingival recession, and root resorption. A number of attempts have been made to create different approaches both preclinically and clinically in order to achieve quicker results. Most attempts can broadly be categorized into biological and surgical approaches. [1,2]

Biological Approach 3

Bone is a dynamic tissue, and it reacts to the external load put on it by modifying its internal as well as external structure.[4] The cellular components within the bone play an intricate role by complex interactions between them to bring about the above-said changes. These cellular components within the bony tissue are osteocytes, osteoblasts, and osteoclast. Osteoblasts line the bone surface and secrete the organic bone matrix (Osteoid), which then gets calcified. Mature osteoblasts which get trapped in this calcified matrix turn into osteocytes. These osteocytes function as a sensor of mechanical load on the bone and initiate bone remodeling involving both the osteoblasts and osteoclasts. This bone remodeling is an essential aspect of orthodontic tooth movement, any attempt to accelerate the orthodontic tooth movement is centered around modifying this remodeling process.

Research in the field of orthodontic tooth movement has revealed that osteoclastic activity is the rate-limiting step, which determines the rate of orthodontic tooth movement. Any attempt to increase the rate of orthodontic tooth movement should

be focused around osteoclast and on the various processes by which osteoclast are recruited and differentiated to initiate bone resorption.

Inflammatory markers like cytokines play an important role in osteoclast recruitment and differentiation, any process leading to an increase in the levels of these proinflammatory markers may increase the rate of tooth movement. There are different methods described in the literature to increase the levels of cytokines locally.[5,6]

The levels of the cytokines can be increased by locally injecting them at the site of orthodontic tooth movement, but this method is not conducive at a clinical level as these inflammatory markers have a very short half- life, when injected and disintegrate before any useful clinical tooth movement can occur.

Another method to raise the levels of these cytokines locally is to induce microtrauma within the bone and the PDL. Procedures such as corticotomy, piezocision and micro-osteoperforations (MOP) are employed to induce trauma, which in turn increase the levels of pro-inflammatory markers such as tumor necrosis factor alpha, interleukin (IL)-1, IL-6 locally.

These procedures can be utilized in a clinical set up to increase the rate of tooth movement temporally.

The concept of the inflammatory cascade and its role in wound healing led to the development of corticotomy facilitated tooth movement by L C Bryan in 1893. It was later re-introduced by Kole in 1959 for rapid movement of the tooth. His method involved osteotomy cuts being placed subapically into the full alveolus to cause bodily tooth movement after application of orthodontic forces. Due to its invasive nature and the amount of surgical trauma, the patient acceptance of this method was limited.

Wilcko et al.[7] reported two cases of de-crowding with the use of corticotomy cuts extending into the cortical bone plates barely entering the medullary space. The biological response to iatrogenic injury with corticotomy results from “Regionally Accelerated Phenomenon” (RAP)[8] as described by Frost, is seen as a consequence of the inflammation of the wound area. This is characterized by transient functional osteopenia followed by accelerated bone turnover over the course of time. The decreased mineral density allows for easier orthodontic movement of teeth during the remodeling and healing. RAP is said to typically peak till about 1–2 months and lasts about 4 months postsurgery. It is regulated by the RANK-RANKL/OPG axis where osteoclast accumulation takes place in the direction of the movement of the tooth and new bone formation at the tension side of the tooth. New bone mineralization takes place at about 20–55 days, where the fibrous tissue is later replaced by bone.

Surgical approach The surgical technique has been documented in many case reports. It is a clinically effective technique used for adult patients, where duration of orthodontic treatment may be critical in selected groups of patients. The PDL and alveolar bone remodeling are the important parameters in tooth movement, and bone turnover is known to increase after bone grafting, fracture, and osteotomy. Several surgical approaches that have been tried in order to accelerate tooth movement were interseptal alveolar surgery, osteotomy, corticotomy, and Piezocision technique.

INTERSEPTAL ALVEOLAR SURGERY

Interseptal alveolar surgery or distraction osteogenesis is divided into distraction of PDL or distraction of the dentoalveolar bone; example of both is the rapid canine distraction. The concept of distraction osteogenesis came from the early studies of limb lengthening. Also from surgical treatments of craniofacial skeletal dysplasia, this concept was later adapted in relation to the rapid tooth movement. In the rapid canine distraction of PDL, the interseptal bone distal to the canine is undermined surgically at the same time of extraction of the first premolars, thus, this will reduce the resistance on the pressure site. In this concept the compact bone is replaced by the woven bone, and tooth movement is easier and quicker due to reduced resistance of the bone. It was found that these rapid movements are during the initial phases of tooth movement especially in the first week as shown. In this technique the interseptal bone is undermined 1 to 1.5 mm in thickness distal to the canine after the extraction of the first premolar, and the socket is deepened by a round bur to the length of the canine.[9,10]

The retraction of the canine is done by the activation of an intraoral device directly after the surgery. It has been shown that it took 3 weeks to achieve 6 to 7 mm of full retraction of the canine to the socket of the extracted first premolars. Rapid canine distraction of the dentoalveolar bone is done by the same principle of the distraction of PDL, with the addition of more dissection and osteotomies performed at the vestibule as shown in . In all the studies done, both techniques accelerated tooth movement with no evidence of significant root resorption, ankylosis, and root fracture. However, there were contradictory results regarding of the electrical vitality test of the retracted canines. Liou reported 9 out of 26 teeth

showed positive vitality, while Sukurica reported that 7 out of 20 showed positive vitality after the sixth month of retraction. So there are still some uncertainties regarding this technique.[11,12,13]

CORTICOTOMY AND OSTEOTOMY

Osteotomy and corticotomy are also surgical techniques that have been clinically used for many years. Osteotomy is when a segment of the bone is cut into the medullary bone and is separated and then moved as a unit as shown in [14]. Corticotomy is one of the surgical procedures that is commonly used in which only the cortical bone is cut and perforated but not the medullary bone, suggesting that this will reduce the resistance of the cortical bone and accelerate tooth movements. It was first tried in orthodontics by Kole [15], where tooth movements were achieved between 6 and 12 months. The technique was further used by others, for example, Grenerson [16] who used this for open bites treatments. In 2001 Wilcko reported that the acceleration of tooth movement is not due to the bony block movement as postulated by Kole it was rather a process of bone remodeling at the surgical site, which was called regional acceleratory phenomenon (RAP). He developed patent techniques which were called accelerated osteogenic orthodontics (AOO) and periodontal accelerated osteogenic orthodontics. Also, modification of RAP was done by adding bioabsorbable grafting material over the injured bone to enhance healing. This technique is reported to have postoperative stability and improved retention but more studies are still needed to be done. The negativity of these surgical techniques is their invasiveness and the acceleration was only in the first 3 to 4 months and it declines with time to the same level of the controls, as shown by others .[17]

Piezocision technique One of the latest techniques in accelerating tooth movement is the Piezocision technique. Dibart .was among the first to apply the Piezocision technique which starts with primary incision placed on the buccal gingiva followed by incisions by Piezo surgical knife to the buccal cortex[18] . Piezocision technique did not cause any periodontal damage as reported by Hassan . Another benefit of this technique is that it can be used with Invisalign, which leads to a better aesthetic appearance and less treatment time as reported by Keser .[19] Piezocision is a promising tooth acceleration technique because of its various advantages on the periodontal, aesthetic, and orthodontic aspects

CONCLUSION

These approaches have successfully reduce treatment times both preclinically and clinically in order to achieve quicker results and accelerate tooth movement.

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