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Review Article

Accelerating the tooth movement: Merging periodontics with orthodontics

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ABSTRACT

One of the main disadvantages of orthodontic treatment procedures is the long duration of treatment. Other side effects include poor oral hygiene leading to dental caries, gingival recession etc. These related intricacies preclude patients from seeking orthodontic treatment. As facial and dental aesthetics has gained importance in recent years, more adult patients are currently showing interest in undergoing orthodontic treatment. These patients tend to desire a shorter treatment time, hence the duration of orthodontic treatment is becoming a matter of major concern. For overcoming this challenge most researchers are seeking different options. Orthodontic tooth movement may be accelerated by several periodontal procedures by enhancing the bone remodelling and turn over. There are several non-surgical and surgical procedures in this regard for hastening the tooth movement. This review aims to discuss the surgical procedures that may accelerate the orthodontic tooth movement.

1. Introduction

Orthodontic treatment is considered as the longest dental procedure performed. We can expect a favourable attitude towards orthodontic treatment if efforts are made to reduce treatment time. Number of adults seeking orthodontic care are on the rise, and they have specific concerns and requirements in relation to aesthetics as well as treatment duration. Overcoming the above-mentioned challenges will surely motivate more people to undertake orthodontic treatment. Tooth movement in Orthodontics results in remodelling of alveolar bone and periodontal ligament (PDL) and occurs because of mechanical stimuli. This clarifies the basic relationship between the specialities of orthodontics and periodontics in treating such patients. Inter disciplinary approach combining tooth movement with principles of periodontal regenerative surgery can produce rapid orthodontic tooth movement.[1] The amount of tooth movement thus achieved depends on the rate at which alveolar bone metabolises and on bone turnover induced by surgical trauma to alveolar bone.[2] The different types of surgical trauma/injury to the alveolar bone are osteotomy, corticotomy, ostectomy and corticotectomy.[3] Surgical trauma of alveolar bone accelerate tissue reorganization and healing by means of localized hard and soft tissue remodelling.[4]

Dentists are in search for techniques for enhanced benefits in orthodontic treatment. Alveolar corticotomy-assisted orthodontic treatment is a technique in orthodontics that is recently gaining wide acceptance and is considered effective in facilitating orthodontic treatment. Periodontally accelerated osteogenic orthodontics (PAOO) is a procedure that joins selective alveolar corticotomy, bone grafting, and the application of orthodontic forces. All these procedures are based on regional acceleratory phenomenon (RAP), a type of bone healing pattern. PAOO had some advantages

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like reduced treatment duration, an increment in width of alveolar bone, reduced resorption of apical root and increased stability post treatment. Different techniques that hasten tooth movement are ultrasonic vibration, ultrasounds, pharmacological approaches, photobiomudulation, micro osteoperforations (MOPs), corticision, and piezocision. This review aims to give an outline of the surgical methods currently used to facilitate tooth movement in orthodontics.

2. Biomechanics

2.1. Mechanism of regional acceleratory phenomenon (RAP).

Herald Frost an Orthopaedist was the first person who found that surgical injury to the osseous tissue will lead to activity near the site of injury. The cascade of physiologic healing events that follow this surgical injury was termed as " The Regional acceleratory phenomenon" (RAP).[5,6] RAP is defined as a localised reaction of tissues to damaging stimuli where by tissue regenerates at a rapid rate than normal in a regional remodelling process.[7] This response alters according to the duration, size, magnitude and intensity of the stimulus. The length of this response depends mainly on the category of tissue involved and in human bone may extend to around four months. The rate of healing of bone occurs 10-50 times sooner than normal bone turnover[8] due to this phenomenon.

The beginning stage of formation of woven bone starts in the periosteum and then extends to medullary bone and reaches a maximum thickness on day seven. Mechanical stability of the bone after injury will be provided by this cortical bridge of woven bone and this is considered a fundamental component of the process of regional acceleratory phenomenon. From the seventh day, in the cortex, woven bone begins to remodel to lamellar bone and in the medulla, the woven bone shows resorption. This process is considered a local osteopenia which is transitory. After formation of new cortical bone, bone in the medulla requires to be restructured to adapt to the newly established cortical integrity. Application of force by orthodontic movement alone is a catalyst enough to set off mild RAP activity. RAP is enhanced if the tooth movement is combined with selective decortication.[9] The catabolic activity is also mediated by osteoclasts. In the long bones RAP starts in a few days following a surgical injury, may peak in one or two months and takes around six to twenty four months to resolve totally.[6] During the process of RAP there is decrease in regional bone densities in healthy tissues but the volume of bone matrix remains constant.

3. Developments till now

3.1. Corticotomy

Corticotomy-assisted (corticotomy-facilitated) orthodontics (CAO) is considered as a treatment procedure in which accelerated bone metabolism is induced by controlled surgical damage which in turn facilitates orthodontic tooth movement. This procedure is considered to be an interconnecting therapy between orthognathic surgery and conventional orthodontics.[10] The concept of accelerating tooth movement surgically was described as early as nineteenth century but various modifications were made during twentieth century. This concept was first described in 1893 by L.C. Bryan. Bichlmayr (1931) used this surgical procedure in patients above 16 years to hasten the correction of severe maxillary protrusion and to reduce relapse. He removed bony wedges to decrease bone volume so that root movement can occur. Köle introduced another technique to hasten orthodontic tooth movement by partial alveolar bone decortication.[10] In this procedure he reflected a mucoperiosteal flap to expose alveolar bone buccally and lingually. Interdental cuts were then made through the cortical bone penetrating the medullary bone slightly. The interdental cuts were then connected using subapical horizontal cuts penetrating the alveolus completely. A bone block was thus created to include one or several teeth and cortical osteotomy was done to separate this block from the remaining alveolus. This technique was called bony block movement. Two cases using corticotomy were published by Generson et al in 1978, and he concluded a cutback in the treatment time. Köle's technique was used by Gantes et al.[11] in five patients with various types of malocclusion. He removed the cortices adjacent to extraction sites. He observed that the overall treatment time in the corticotomy group was 14.8 months and in the control group, it was 28.3 months. Suya clarified the work done by Köle and did surgical treatment on 395 patients using corticotomy-assisted orthodontics. Instead of horizontal osteotomy cut used in Kole's technique, he used supra-apical horizontal corticotomy cuts. It took six to twelve months to finish the treatment. Based on the results obtained, he concluded that his procedure produced less pain, root resorption and recurrence. He recommended a time period of three to four months for completion of tooth movement by which time the edges of the bone blocks would begin to fuse. This procedure solved the difficulties in treating some clinical situations like crowding, retraction of canine after premolar extraction, slow orthodontic expansion, intrusion of molars for prosthetic reasons and for open bite correction, impacted tooth eruption and improvement of stability achieved after orthodontic treatment.[12]

Concept of Compression Osteogenesis (CO) was the modification of CAO procedure.[13] Molar intrusions required some amount of corticotectomy, depending on

how much intrusion was needed. When elastic traction was done buccally and lingually with100-150 grams per side using micro screws and miniplates, a 3mm intrusion was noted after two months. The above method may be delegated as CO rather than CAO. The main disadvantage of this procedure is that even when done after premolar extractions, the cortical plates in the palatal region may limit the displacement at the level of apices of incisors. This problem may be resolved by giving a horizontal labial corticotomy and a horizontal palatal corticotectomy behind the upper incisor. Instead of displacing teeth through the bone, a pedicled bone block along with medullary bone can be moved. For this procedure, a sufficient anchorage from bone plates on palate must be put in using high orthopedic force of 500-900 grams. The main limitation of CO is that since bone block together with teeth is moved, the movement will be substantial and unstable compared to CAO where the displacement is in the weakened alveolar bone. To resolve the situations like lack of stability post orthodontic treatment and thin mandibular cortices which may result in bony dehiscence, techniques that expand the volume of alveolar bone together with grafts can be tried.

3.1.1. Advantages[14]

1. Successful in accelerating tooth movement.
2. Bone augmentation can be achieved.

3.1.2. Disadvantages

1. Morbidity inherent with the technique is high
2. It is an invasive procedure
3. Vital structures in the adjacent areas can get damaged
4. The procedure can cause swelling, postoperative pain, infection and rarely necrosis.
5. There is low patient acceptance of the procedure

3.2. Dentoalveolar distraction

This is a technique of mechanically stretching pre-existing bone tissue to grow new bone. New bone forms at a rate of approximately 1 mm per day in the gap of osteotomy or corticotomy. Liou and Huang[15] gave the concept of "dental distraction" in which canine distalization time is quickened to three weeks by distracting the periodontal ligament. An intraoral distraction device is used in this technique to modify the extraction socket immediately post extraction by undermining the interseptal bone distal to the canines.

3.3. Wilckodontics

In 2001 Wilco reported that the accelerated tooth movement as postulated by Kole is not due to the bony block movement.[10] He postulated that bone remodelling at the surgical site was due to the process of regional acceleratory phenomenon (RAP). He reported that corticotomized patients showed a temporary localized demineralizatio remineralization process which was consistent with RAP. This was confirmed by observations on a surface computed tomographic evaluation. Wilco developed and patented the techniques of accelerated osteogenic orthodontics (AOO) and periodontally accelerated osteogenic orthodontics (PAOO). To improve RAP and accelerate healing, bio absorbable grafts may be added over the injured bone. This technique showed improved retention and postoperative stability, but further studies must be conducted to substantiate these results. The main mechanism is the induction of acute inflammatory process intentionally there by increasing the levels of inflammatory mediators like prostaglandins (PGs) and cytokines, thereby increasing tooth movement.[16]

3.3.1. PAOO is contraindicated in[14]

1. Patients who have active periodontal disease.
2. Patients in whom endodontic treatment is not performed adequately.
3. Patients with a history of long-term corticosteroid usage.
4. Patients who are on medications that interfere with bone metabolism like bisphosphonates or nonsteroidal anti inflammatory drugs.

3.3.2. Advantages

1. This procedure has been proven to accelerate tooth movement.
2. Bone can be augmented to prevent periodontal defects.

3.3.3. Disadvantages

1. The high morbidity inherent with the procedure.
2. Invasiveness of the procedure.
3. Vital structures in the adjacent areas can get damaged.
4. The procedure can cause swelling, postoperative pain, infection, and rarely vascular necrosis.
5. Low patient acceptance.

3.4. Corticision

This technique was introduced by Kim et al to produce surgical trauma to bone using a flapless procedure. One of the advantages of this technique is lack of flap elevation. Kim et al.[16] and Park[12] used a fortified scalpel and mallet to cut through gingiva and cortical bone without flap elevation. The surgical trauma thus produced was enough to initiate the RAP effect and hasten orthodontic tooth movement.

The main drawbacks of the procedure include:[17]

1. Grafting cannot be performed with this procedure.
2. The repeated malletting may lead to dizziness after the procedure.
3. Scalpel breakage and injuries may occur.

3.5. Piezocision

Piezocision is a new surgical approach which is a minimally invasive procedure done without flap elevation to overcome patient discomfort. Dibart was the first person to describe piezocision, as a combined approach of corticision along with grafting offered by PAOO in the year 2009. To initiate regional acceleratory phenomenon, a combination of micro-incisions in the buccal gingiva and piezoelectric knife are used for alveolar bone decortication. This technique allows for hard and soft tissue grafting to correct bone defects or gingival recessions through judicial tunnelling. Surgery utilizing piezoelectric device utilize ultrasonic micro vibrations at a frequency below 50 kHz to ensure cutting of brittle mineralized tissue there by sparing the soft tissues. Because of the micrometrical and selective cut produced without any osteonecrosis, a piezoelectric device permits guarded and accurate osteotomies.[18,19] Piezoelectric devices also reduced the necessity for excessive force. All areas are sutured to limit scarring. The patient experience minimum discomfort with this technique. The main limitation is that cuts are made blindly without reflection of flap. Navigation surgical stents may be used to avoid root injuries.

3.6. Micro-osteoperforations (MOP)

This is a new minimally invasive technique that accelerates tooth movement also called Alveocentesis. This procedure does not involve incision or elevation of flap preceding osteoperforation. Micro-osteoperforations are created using Propel (Propel Orthodontics, USA). This device punctures bone to hasten the tooth movement. The mechanism by which this technique accelerates tooth movement is by over expression of inflammatory mediators that cause a rise in osteoclastic activity more than during normal orthodontic tooth movement.[20] A trial was conducted in 20 adult patients with Class II division 1 malocclusion by Alikhani using this technique.[20] To enhance tooth movement, three micro perforations without elevation of flap were performed on the distal aspect of canines six months after extraction of premolars.

3.6.1. Limitations are[17]

1. There is minimal injury to the bone
2. It is a blind procedure.
3. Hard or soft tissue grafting is not possible during the procedure.
4. The procedure is time-consuming and expensive.

3.7. Laser

It is a novel approach for PAOO. Low intensity laser therapy (LILT) decreases patient discomfort because of biostimulatory effect. The mechanism involves activation of cytochrome C and production of ATP. Low energy laser irradiation enhances the rate of tooth movement through RANK/RANKL, macrophage colony stimulating factor and its receptor. Corticotomy using laser can be used as a non-invasive procedure that decreases treatment time and trauma to the periodontium. Erbium, Chromium doped Yttrium Scandium Gallium Garnet (Er-Cr: YSGG) laser irradiation accelerates orthodontic tooth movement by reducing the cortical bone layer without surgical flap elevation.[21] Laser stimulation has been shown to increase bone repair, which may be utilized to accelerate healing post-surgery or in implant procedures.[14]

Kawasaki and Shimizu in a study concluded that due to cellular stimulation promoted by LILT, orthodontic movement in laser irradiated teeth in rats was 30% faster than nonirradiated rats.[22] Different variables for different lasers have proven to be useful in inducing changes within cell cultures and increasing the healing effect.[23] The bio stimulatory effects of lasers on bone repair are directly dependent on the dose applied.

3.8. Monocortical tooth dislocation and ligament distraction (MTDLD)

This technique is a combination of two different movements done separately but simultaneously on opposite root surfaces. Around each root, microsurgical corticotomies in both vertical and horizontal directions using a microsaw used in piezosurgery are performed in cortical bone in the direction of movement to eliminate resistance. A rapid dislocation of root and cortical bone is brought about by the instant use of powerful biomechanical forces. Opposite to this movement, a fast distraction of periodontal ligament fibres on the root surface is produced by the dislocation force. Application of usual biomechanics of orthodontics following this osteogenic process attains final tooth movement.[24]

4. Conclusions

Currently, several surgical techniques that aim to achieve accelerated tooth movements are gaining acceptance. Attempts to reduce the traumatic injury and appointment time are important points to be contemplated when developing new techniques. Understanding the biomechanics of bone remodelling will widen the scope of corticotomy facilitated orthodontics with or without the use of alveolar augmentation. Several clinical modifications have been designed and studied to compare flap versus flapless techniques and decortication using piezoelectric knifes.

Techniques that hasten tooth movements in orthodontics are applicable only if they benefit patients and when benefits exceed probable risks or complications. Certain procedures are becoming popular (piezocision, MOPs), while others (corticision, rapid canine retraction) are not, because of

finite applications, discomfort and invasive procedures. Piezocision and PAOO are advantageous because of grafting used in surgery which permits refinement of the hard and soft tissues. Piezocision, MOPs, and corticision are approaches that bring about minimum invasiveness and are performed without flap elevation. Among these procedures, MOP is the least invasive technique and PAOO the most invasive one. When compared to other techniques, the one that creates considerable response to injury and effect bone metabolism is the use of piezoelectric knife. These new additions to orthodontic treatment with upcoming periodontal procedures within the same bony platform has made adult orthodontics a possibility. With the current evidence available, we cannot distinctly discern how much treatment time reduction will be obtained with these techniques. All the above-mentioned procedures could be attractive treatment options and be a hand in hand affair for the doctor as well as the patient if proper research is attempted to relieve the adverse outcomes associated with these procedures. Controlled clinical trials using larger samples for longer periods are warranted to differentiate the effectiveness of various techniques and to eliminate possible side effects.

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6. Conflict of Interest

None.

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