International Journal Dental and Medical Sciences Research (IJDMSR)
ISSN: 2393-073X Volume 2, Issue 12 (Dec- 2018), PP 09-15
www.ijdmsr.com

Various Surgical Methods to Accelerate Orthodontic Tooth Movement. A Review

Dr. Shahzaib Nasti (Consultant Maxillofacial Surgeon), Dr. Shaeeb Rashid (Consultant Orthodontist)
**Corresponding Author: Dr. Shahzaib Nasti*

I. INTRODUCTION

Orthodontic treatment is based on the principle that when force is delivered to a tooth and transmitted to the adjacent investing tissues, certain mechanical, chemical, and cellular events take place within these tissues, which allows structural alterations and contribute to the movement of the tooth. Barlow reported that teeth move 0.8 – 1.2 mm/month when continuous forces are applied[1].

Attempts to accelerate the rate of tooth movement are being made to eliminate the risk of gingival inflammation, decalcification, dental caries, and root resorption which are generally associated with longer treatment duration. Various methods that accelerate the tooth movement are documented in the literature which includes:

1. Surgical Methods.
   i. Regional acceleratory phenomenon(RAP)
   ii. Corticotomy
   iii. Wilckodontics
   iv. Novel approaches for PAOO
   - Lasers
   - Microosteoperforation
   - Piezocision
   - Interseptal alveolar surgery
   - Monocortical tooth distraction and ligament distraction(MTDLD) technique

2. Non-surgical Methods
   i. Device assisted therapy or Mechanical stimulation methods.
   - Vibration
   - Photobiostimulation
   - LLLT
   - LED
   - LIPUS

   ii. Drugs.

I. SURGICAL METHODS

Different surgical techniques have been documented in many case reports. It is a clinically effective technique used for adult patients, where duration of orthodontic treatment may be critical. Periodontal ligament (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 are Corticotomy and Piezocision technique.[2]

The idea of surgical acceleration came into being after the introduction of Regional Acceleratory Phenomenon (RAP) by Frost in 1983. RAP is a local response to noxious stimulus, by which tissue form faster than the normal regional regeneration process. This phenomenon causes healing to occur 2–10 times faster than normal physiologic healing by enhancing the various healing stages.[3]

II. REGIONAL ACCELERATORY PHENOMENON (RAP)

Orthopedist Harold Frost, recognised that surgical wounding of osseous tissue results in striking reorganising activity adjacent to the site of injury (in osseous/ soft tissue surgery). He collectively termed this

cascade of physiologic healing events –"The Regional acceleratory phenomenon" (RAP).[4-5] The RAP is a local response of tissues to noxious stimuli by which tissue regenerates faster than normal in a regional regeneration/remodeling process.[6] This response varies directly in duration, size, and intensity with the magnitude of the stimulus. The duration of RAP depends on the type of tissue, and usually lasts about four months in human bone. This phenomenon causes bone healing to occur 10-50 times faster than normal bone turnover.[30]

In humans long bones, following surgical injury, RAP begins within a few days, usually peaks at 1-2 months, and may take from 6 to 24 months to subside completely.[5] RAP results in a decrease in regional bone densities (osteopenia) in healthy tissues where as the volume of bone matrix remains constant.[4] Orthodontic force application alone is a stimulant sufficient to trigger mild RAP activity. But when tooth movement is combined with selective decortication, RAP is maximized.[7-8]

However, in 2001 Wilcko et al. revisited the original technique of bony block movement with some modifications. He attempted two cases with severely crowded dental arches, and speculated that the dynamics of physiologic tooth movement in patients who underwent selective decortication might be due to a demineralization-remineralization process rather than bony block movement. They suggested that this process would manifest as a part of RAP that involves the alveolar bone after being exposed to injury (corticotomy) and during active tooth movement.[9]

III. CORTICOTOMY

It was first tried in orthodontics by Kole.[10] Conventional 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. This will reduce the resistance of the cortical bone and accelerate tooth movement. It was suggested that bony blocks were created as a result of the corticotomy, hence causing faster tooth movement.[11]

The conventional corticotomy procedure involves elevation of full thickness mucoperiosteal flaps, bucally and/or lingually, 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.

Until 2001, the "bony block" concept prevailed as a misconception. However, Wilckoet al[9] reported that tooth movement was not the result of bony block, but rather a process of transient remineralization /demineralization which is a concept of reversible osteopenia in the bony alveolar housing consistent with wound healing pattern of RAP. He also introduced the term "bone matrix transportation" and developed patent techniques which were called Accelerated Osteogenic Orthodontics (AOO) and Periodontal Accelerated Osteogenic Orthodontics. Modification of RAP was done by adding bioabsorbable grafting material over the injured bone to enhance healing.[9]

IV. DURATION OF RAP AFTER CORTICOTOMY:

Studies comparing the rate of tooth movement showed that the tooth movement peaked at 22-25 days and then decelerated. During this three week period, corticotomy facilitated side moved twice than the control side. Similar results were obtained in a study conducted in adults to retract maxillary canines following premolar extractions. Based on the outcome of these studies the length of RAP was probably four months, after which the rate of tooth movement returns to normal.

Effect of corticotomy on the treatment time for adults:

Reviews on corticotomy claim that it shortens the treatment time. However, one cannot measure treatment time without measuring treatment quality. The American Board of orthodontics has developed a detailed grading system to assess the quality of orthodontic treatment. Yet to date there are no RCT's focusing on this aspect of corticotomy.

WILCKODONTICS

As early as 1950s, periodontists began using a corticotomy technique to increase the rate of tooth movement. An oral corticotomy is surgical procedure where cuts are made in the alveolar bone. In the 1990s, Dr Wilcko, using computed tomography, discovered that reduced mineralization of the alveolar bone was the reason behind the rapid tooth movement following corticotomies. They used their knowledge of corticotomy and their observations of RAP to develop their patented periodontally accelerated osteogenic orthodontics (PAOO) technique in 1995.[9]

Wilckodontics is a comparatively new sub-branch which aids in providing an increased net alveolar volume after orthodontic treatment. This is also called the PAOO technique. It is a combination of a selective decortication facilitated orthodontic technique and alveolar augmentation. With this technique, one is no longer at the mercy of the pre-existing alveolar volume, and teeth can be moved 2 to 3 times further in 1/3 to ¼ the time required for traditional orthodontic therapy. The same phenomenon was described simultaneously in the periodontal literature by Yaffe et al. Gantes in 1990 reported on corticotomy-facilitated orthodontics in five adult patients in whom space closing was attempted with merely orthodontic forces. More recently, Drs William and Thomas Wilcko have demonstrated rapid orthodontic tooth movement following selective labial and lingual decortication of alveolar bone in the area of desired tooth movement using a technique called accelerated osteogenic orthodontics tooth movement (AOOTM) orthodontics force.[9]

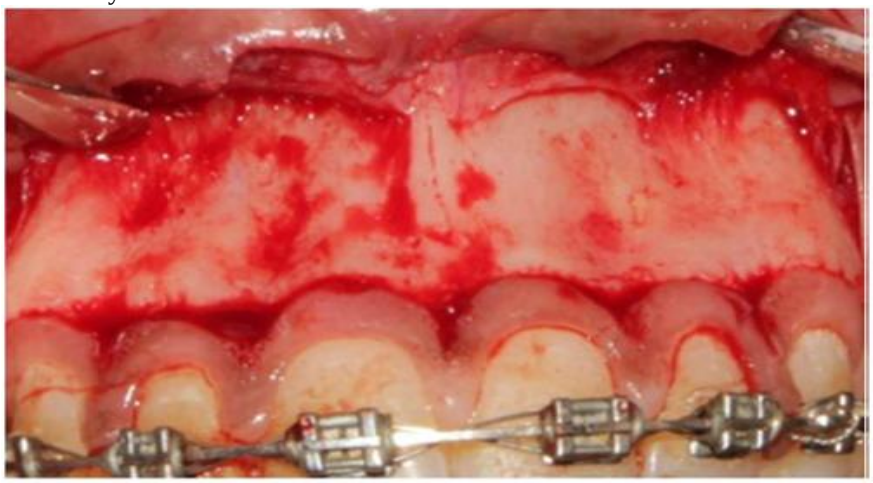
The Wilcko brothers gave a novel dimension to historical achievements so far and said in selectively decorticated patients it was discovered that the rapid tooth movement was not the result of bony block movement, but rather to a transient localized demineralization-remineralization phenomenon in the bony alveolar housing consistent with the wound healing pattern of the regional acceleratory phenomenon. The demineralization of the alveolar housing over the root surfaces apparently leaves the collagenous soft tissue matrix of the bone, which can be carried with the root surface and then remineralizes following the completion of the orthodontic treatment. The Wilcko duo further emphasized on the degree of tissue metabolic perturbation per se for this rapid orthodontic movement.

Indications

1. PAOO can contribute to increased bone volume. PAOO can prevent the formation of new fenestrations and dehiscences and correct the existing ones.
2. Crossbites and tooth size-arch length discrepancies.
3. Traditional orthodontics can satisfactorily address crowding up to 5 mm whereas; this can be extended to 10-12 mm if PAOO technique is utilized.
4. Conservative approach rather than orthognathic surgery (except for severe class III skeletal dysplasia), PAOO can be used as an alternative to orthognathic surgery in some cases.
5. Where extractions are contraindicated due to facial profile and limited expansion due to reduced buccolingual width of the alveolar ridge.
6. Moderate to severe malocclusions like severe bimaxillary protrusion and cleft lip palate cases.
7. Uprighting of tipped molars and intrusion of supraerupted molars.
8. To treat impaction cases at a faster rate.

Contraindications

1. Active periodontal disease.
2. As an alternative for surgically assisted palatal expansion in the treatment of severe posterior crossbite.
3. Should not be attempted in cases where the bimaxillary protrusion is accompanied with a gummy smile, which might benefit more fromsegmental osteotomy.
4. Severe skeletal class III – prognathic mandible.
5. Uncontrolled over-all systemic disease.



Reflection of full thickness flap (Source: internet)

Vertical corticotomy using no 2 carbide bur (Source Internet)

Modification of CAO procedure:

A) Compression osteogenesis (CO):

Procedures like molar intrusion may be designated with CO instead of CAO (corticotomy accelerated osteogenesis), as the medullary bone and overlying mucosa supports the tooth bone block .The CO concept is similar to CAO concept, but uses corticotectomy instead of corticotomy. CAO causes movement of teeth in the weakened alveolar bone but CO causes movement of bone block along with teeth.

Kanno et al, used CO procedure to treat severe open bite case and obtained desired results in 6 months by moving the upper posterior bone tooth segments 7mm in a posterior direction and using anchor plates and elastics after 3 weeks of surgery.

B) Alveolar corticotomies (ACS):

ACS are defined as a surgical intervention limited to the cortical portion of the alveolar bone. Whereas in osteotomies both cortical and trabecular bone material is removed in considerable quantities. In ACS the incision must pierce the cortical layer, and at the same time, penetrate into the bone marrow only minimally.[12]

Novel approaches for PAOO

Lasers

Laser assisted flapless corticotomy is a useful non-invasive procedure for reducing treatment time and damage to periodontium. It enhances the orthodontic tooth movement by reducing the cortical bone layer (resistant to bone re-sorption relative to spongious bone) following Erbium, Chromium doped Yttrium Scandium Gallium Garnet (Er-Cr: YSGG) laser irradiation, without surgical flap reflection.[13]

Micro-Osteoperforations (MOP)

To further reduce the invasive nature of surgical irritation of bone, a device called Propel, was introduced by Propel Orthodontics. They termed this process as Alveocentesis which literally translates to puncturing bone.[14] The use of this device in animals has shown that performing micro-osteoperforations (MOPs) on alveolar bone during orthodontic tooth movement can stimulate the expression of inflammatory markers which leads to increase in osteoclast activity and rate of tooth movement.

Mani Alikhaniet al[14] performed a single center single blinded study to investigate this procedure on humans. He found that MOPs significantly increased the expression of cytokines and chemokines which are known to recruit osteoclast precursors and stimulate osteoclast differentiation. MOPs increased the rate of canine retraction 2.3-fold compared to the control group.

Micro-osteoperforation (Source: Internet)

1. Patients reported mild discomfort locally at the spot of the MOPs. At days 14 and 28, little to no pain was experienced.
2. MOPs are an effective, comfortable, and safe procedure to accelerate tooth movement during orthodontic treatment.
3. MOPs could reduce orthodontic treatment time by 62%.
4. However, this was the first study investigating the MOPs method and certain issues were not addressed, such as, effect on root resorption, number of perforations required, long term effects (this study had a duration of only 28 days).

Piezocision technique

One of the recent techniques inaccelerating tooth movement is the Piezocision technique.[15] Dibart was amongst the first to apply the Piezocision technique which starts with primary incisionplaced on the buccal gingiva, below the interdental papilla, as far as possible, in the attached gingiva using a No.15 scalpel. These incisions need to be deep enough so as to pass through the periosteum and contact the cortical bone. Next, using ultrasonic instrumentation (they used a BS1 insert Piezotome), perform the corticotomy cuts to a depth of 3 mm through the previously made incisions. At the areas requiring bone augmentation, tunneling is performed using an elevator inserted between the incisions, to create sufficient space to accept a graft material. No suturing is required except for the areas where the graft material needs to be stabilized. Piezocision technique does not cause any periodontal damage as reportedby Hassan.[16]

Piezocision. (Source: Internet)

The study by Keser concluded that this technique can be used with Invisalign which leads to abetter aesthetic appearance and also the treatment time is shortened. Piezocision is a promising toothacceleration technique because of its various advantageson the periodontal, aesthetic, and orthodontic aspects.

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.[3] 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 reducing the resistance on the pressure site. In this technique, the compact bone is replaced by the woven bone, and tooth movement is easier and quicker due to reduced resistance of the bone.[17] These rapid movements are during the initial phases of tooth movement especially in the first week. 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. The retraction of canine is done by activation of an intraoral device immediately after surgery. It has been shown that it took 3 weeks to achieve 6 to 7 mm of full retraction of the canine into the socket of extracted first premolars.[18]

In all the studies done, this technique showed accelerated tooth movement with no evidence of significant root resorption, ankyloses or root fracture. However, there were contradictory results regarding the electrical vitality test of the retracted canines. Liou reported that 9 out of 26 teeth showed positive vitality, while Sukurica reported that 7 out of 20 showed positive vitality aftersix months of retraction. So uncertainties regarding this technique still prevail.

Monocortical tooth dislocation and ligament distraction (MTDLD) technique:

The MTDLD technique combines two different dental movements that work separately but simultaneously on opposite root surfaces. On the root surface corresponding to the direction of movement, vertical and horizontal microsurgical corticotomies are performed around each tooth root with a piezosurgical microsaw to eliminate cortical bone resistance. The immediate application of strong biomechanical forces produces rapid dislocation of the root and the cortical bone together. On the root surface opposite the direction of movement, the dislocation force produces rapid distraction of ligament fibers. During the osteogenic process that follows, application of normal orthodontic biomechanics achieves the final tooth movement.[19]

TomasoVercellotti, Andrea Podesta et al have developed a new surgical-orthodontic technique to maximize the rapidity of movement and prevent damage to the periodontal tissues. These goals may be achieved with a piezosurgical technique that permits microsurgical corticotomy around each root and the immediate application of biomechanical force. This technique avoids involvement of the periodontal tissue fibers, which is necessary in traditional orthodontic movement, thereby preventing periodontal and bone resorption. The greatest amount of dental movement occurs in approximately the first 30% of total treatment time with the MTDLD technique.[20-21]

V. CONCLUSION

The field of orthodontics continues to evolve with continued technological innovations and research. The most recent popular advances have been in the fields of acceleration of orthodontic tooth movement to shorten overall treatment times. The current methods such as piezocision, microosteoperforations, lasers and vibration have reduced or eliminated the invasive nature of previous procedures used to achieve the Regional Acceleratory Phenomenon. Also, they come with additional advantages such as reduced rates of relapse, reduced orthodontic pain and reduced root resorption.

In addition, technology has changed the way orthodontic problems are diagnosed and treated. All of these advances have expanded the patient populations seeking treatment and have improved what clinicians can expect when treating patients.

BIBILIOGRAPHY

[1]. Barlow M, Kula K. Factors influencing efficiency of sliding mechanics to close extraction space: A systematic review. Orthod Craniofac Res. 2008;11(2):65-73.
[2]. Frost, H. M. The regional acceleratory phenomenon: a review. Henry Ford Hospital Medical Journal. 1983;31(1):3.
[3]. Nimeri, G., Kau, C. H., Abou-Kheir, N. S., Corona, R. Acceleration of tooth movement during orthodontic treatment-a frontier in Orthodontics. Progress in orthodontics. 2013;14(1):42.

[4]. Frost MH. The biology of fracture healing: An overview for clinicians Part I. Clin Ortho. 1989;248:283-93.
[5]. Frost MH. The biology of fracture healing: An overview for clinicians Part II. Clin Ortho. 1989;248:294-309.
[6]. Frost HM. The regional acceleratory phenomenon: a review. Henry Ford Hosp Med J. 1983;31:3–9.
[7]. Schilling T, Müller M, Minne HW, Ziegler R. Influence of inflammation-mediated osteopenia on the regional acceleratory phenomenon and the systemic acceleratory phenomenon during healing of a bone defect in the rat. Calcif Tissue Int. 1998;63:160–6.
[8]. Generson RM, Porter JM, Stratigos GT. Combined surgical and orthodontic management of anterior open bite using corticotomy. J Oral Surg. 1978;36:216–9.
[9]. Wilcko WM, Wilcko T, Bouquot JE, Ferguson DJ. Rapid orthodontics with alveolar reshaping: two case reports of decrowding. Int J PeriodontRestorat Dent. 2001;21: 9–19.
[10]. Köle H. Surgical operations of the alveolar ridge to correct occlusal abnormalities.Oral SurgOral Med Oral Pathol. 1959;12:515-29.
[11]. Kole H. Surgical operations on the alveolar ridge to correct occlusal abnormalities.Oral Surg Oral Med Oral Pathol. 1959;12: 413-20.
[12]. Chung KR, Kim SH, Lee BS. Speedy surgical-orthodontic treatment with temporary anchorage devices as an alternative to orthognathic surgery.Am J OrthodDentofacialOrthop.2009; 139: 787–98.
[13]. MassoudSeifi, FarnazYounessian, NazilaAmeli. The innovated laser assisted flapless corticotomy to enhance orthodontic tooth movement. J Lasers in Med Sci. 2012; 3:1-12.
[14]. Alikhani, M., Raptis, M., Zoldan, B., Sangsuwon, C., Lee, Y. B., Alyami, B., Teixeira, C. Effect of micro-osteoperforations on the rate of tooth movement. American Journal of Orthodontics and DentofacialOrthopedics. 2013;144(5):639-648.
[15]. Dibart, S., Sebaoun, J. D., &Surmenian, J. Piezocision: a minimally invasive, periodontally accelerated orthodontic tooth movement procedure CompendContinEduc Dent, 2009:30:342–350.
[16]. Hassan N, Sa IT. The effect of using piezocision technique in orthodontic tooth movement on the periodontal condition. Egypt Dent J. 2011; 57:3047.
[17]. Keser EI, Dibart S. Piezocision-assisted Invisalign treatment. CompendContinEduc Dent. 2011; 32(2):46–8. 50–41.
[18]. Liou EJ, Huang CS. Rapid canine retraction through distraction of the periodontal ligament. Am J OrthodDentofacialOrthop. 1998; 114(4):372–82.
[19]. TomasoVercellotti, Andrea Podesta. Orthodontic oicrosurgery: A new surgically guided technique for dental movement. Int J Periodontics Restorative Dent.2007; 27: 325-31.
[20]. Vercellotti T, Nevins ML, Kim DM, et al. Osseous response following resectivether-apy with piezosurgery. Int J Periodontics Restorative Dent.2005; 25: 543-49.
[21]. Chiriac G, Herten M, Schwarz F, Rothamel D, Becker J. Autogenousbonechips: Influence of a new piezoelectric device (Piezosurgery) on chip morphology, cell viability and differentiation. J ClinPeriodontol.2005; 32: 994-99.

Corresponding Author: Dr. Shahzaib Nasti