 DOI: 10.18231/2455-6785.2017.0014

Accelerated Orthodontics: A paradigm shift

Mayur Shingade[1], Rajkumar Maurya[2], Harsh Mishra[3,*], Harpreet Singh[4], Kunal Agrawal[5]

[1]Reader, Dept. of Oral & Maxillofacial Surgery, [2]Assistant Professor, RR Hospital, New Delhi, [3]Reader, [5]Senior Lecturer, Rishiraj College of Dental Sciences, Bhopal, Madhya Pradesh, [4]Associate Professor, Dept. of Orthodontics, ESIC Dental College Hospital, New Delhi

***Corresponding Author:**
Email: dr.mishraharsh@gmail.com

Abstract

Extended orthodontic treatment duration can be associated with increased risks of root resorption, periodontal disease, caries and changes or loss of patient motivation. Various attempts have been made to increase the rate of tooth movement while minimizing the associated side effects. It can be broadly classified into invasive, minimal invasive and non-invasive approaches. Surgically derived regional accelerations of orthodontic treatment i.e. PAOO, dento-alveolar & periodontal distraction and its modifications come under invasive category. Among minimal invasive methods, surgical procedure have been modified from raising a flap to flap less techniques such as peizosicion, corticision and aleveocentesis are becoming popular. Among the non-invasive methods various physical devices & pharmacological agents have been proposed. There have been several publications describing a positive effect of vitamin D, prostaglandin E1 and 2 Osteocalcin, parathyroid hormone, long-term or high dose corticosteroids and thyroxin on OTM. Although some of them were successful, the major drawback to most of these treatment interventions is the necessity for systemic delivery and the ensuing systemic side effects of pharmacological agents. Alternatively, local delivery requires repeated painful injections, necessitates demanding scheduling challenges with the need for repeated and frequent treatment. Physical devices like Acceledent, Orthopulse, Propel Device, Biolux & Aevo system have been tried to accelerate orthodontic tooth movement. Present article demonstrated practical utility of the above-mentioned techniques and associated difficulties considering Indian Orthodontic practice.

Keywords: PAOO, LLLT, Acceledent

Introduction

Patient's number one concern before starting orthodontic treatment is how long treatment will take. In the past two decades, new devices and modalities have made the orthodontic process more efficient, but not faster. Many innovations have been introduced to improve bracket design and treatment protocols, however the only effective techniques to increase the speed in which teeth move through alveolar bone involve extensive surgery.(1) The challenge has been how to locally accelerate bone remodeling in a non-invasive manner. Various attempts have been made to increase the rate of tooth movement while minimizing the associated side effects. It can be broadly classified into invasive, minimal invasive and non-invasive approaches. Surgically derived regional accelerations of orthodontic treatment i.e. PAOO, dento-alveolar & periodontal distraction and its modifications come under invasive category. Among minimal invasive methods, surgical procedure have been modified from raising a flap to flap less techniques such as peizosicion, corticision and aleveocentesis are becoming popular. Among the non-invasive methods various physical devices & pharmacological agents have been proposed. There have been several publications describing a positive effect of vitamin D, prostaglandin E1 and 2 Osteocalcin, parathyroid hormone, long-term or high dose corticosteroids and thyroxin on OTM.(2) Although some of them were successful, the major drawback to most of these treatment interventions is the necessity for systemic delivery and the ensuing systemic side effects of pharmacological agents. Alternatively, local delivery requires repeated painful injections, necessitates demanding scheduling challenges with the need for repeated and frequent treatment. Physical devices like Acceledent, Orthopulse, Propel Device, Biolux & Aevo system have been tried to accelerate orthodontic tooth movement. Present article demonstrated practical utility of the above-mentioned techniques and associated difficulties considering Indian Orthodontic practice.(3)

Review of Literature

Surgical intervention to affect the alveolar housing, and thereby tooth movement has been described in different forms over the past 100 years. Heinrich Kole was the first to describe corticotomy-facilitated orthodontics in 1959.(4) They believed that the continuity and thickness of the denser layer of cortical bone offers the most resistance to rapid tooth movement. Kole attributed the accelerated tooth movement by selective corticotomy to moving "blocks of bone" and this interpretation of the rapid tooth movement prevailed until Wilcko's publication in 2001.Wilcko discovered that the rapid tooth movement was due to transient localized demineralization-remineralization process in the bony alveolar housing and was not the result of bony block movement as suggested by Kole.(5) Wilcko et al combined the refined corticotomy-facilitated

orthodontic technique with alveolar augmentation using particulate bone graft and named the orthodontic and periodontal aspects of this procedure the accelerated osteogenic orthodontics (AOO) technique, and more recently, the periodontally AOO (PAOO) surgical technique, respectively reduce the orthodontic treatment time to 1/3rd the time of conventional orthodontics in majority of cases.[6]

Cruz et al in 2004 were the first to carry out a human study on the effect of low-intensity laser therapy on orthodontic tooth movement. They showed that the irradiated canines were retracted at a rate of 34% greater than the control canines over a period of 60 days.[7] An alternative surgical approach to accelerate tooth movement was introduced by Park et al in 2006 known as 'corticision' which was considered to be a micro-invasive technique.[8] Vercelotti and Podesta in 2007 introduced the use of piezosurgery, instead of burs, in conjunction with the conventional flap elevations to create an environment conducive to rapid tooth movement.[9] Dibart et al in 2009 described a minimally invasive procedure piezocision, which used a piezoelectric knife instead of mallet to give labial/buccal cortical incisions with no involvement of palatal or lingual cortex.[10] A new micro-invasive technique called alveo-centesis was introduced in 2011, which stimulates cytokine activity thereby, accelerating alveolar bone remodeling. This new technique called the PROPEL system has been developed and patented for use as a simple, in-office procedure to stimulate alveolar bone remodeling. The micro-osteo-perforations created by PROPEL system harnesses the body's own biology to create a cytokine effect and allows the teeth the move into clinically desired position in a more predictable and faster manner.[11]

Invasive procedures: These include corticotomy-facilitated tooth movement and PAOO. Although highly predictable, these procedures are very invasive and involve a lot of risk as well as postoperative complications. These procedures are based on the principle of regional acceleratory phenomenon (RAP) which is a part of healing event and is a localized osteoporosis state. The two main features of RAP include decreased regional bone density and accelerated bone turnover, which are believed to facilitate orthodontic tooth movement. By enhancing the various healing stages, corticotomy-facilitated tooth movement makes healing occur 2–10 times faster than normal physiologic healing.[5] Corticotomy-facilitated tooth movement technique doubled the rate of orthodontic tooth movement. (Fig. 1) Histologically, the more active and extensive bone remodeling suggested that the acceleration of tooth movement associated with corticotomy is due to increased bone turnover and based on a RAP. PAOO is a modified corticotomy facilitated orthodontic technique with the addition of alveolar augmentation which has an advantage of increasing the volume of alveolar bone and allows for correction of preexisting bony dehiscences and fenestrations. Potential advantages of the PAOO technique apart from reducing orthodontic treatment time from 1/3rd to 1/4th of traditional orthodontic treatment are that it also widens the scope of malocclusion treatment by enhancing the limits of tooth movement, decreases need for extractions, and enhances post orthodontic stability. It is useful for subtle enhancement of patient's profile by alveolar reshaping, less root resorption due to reduced resistance of bone, and for simultaneous rapid recovery of shallow unerupted teeth. Autogenous bone graft, allograft/xenograft (demineralized freeze-dried bone allograft (DFDBA) and alloplastic materials can be used, however each have their own disadvantages. The disadvantage of using autogenous bone graft in lateral augmentation procedure is that it undergoes extensive resorption. Bovine bone xenograft provides only 37% of bone-to-graft contact after 6–7 months and biopsies from DFDBA-filled extraction sockets showed dead DFDBA particles embedded in dense connective tissue with little to no new bone formation. A recent study revealed that alloplastic material (bioactive glass) was not able to contribute to vertical ridge augmentation and only a small gain in horizontal ridge width (average 1.1 mm) occurred 6 months after a guided bone regeneration procedure. PAOO is efficacious in the treatment of class I malocclusion with moderate to severe crowding, class II malocclusion requiring extraction/expansion, and mild class III cases. Initiation of orthodontic force should not be delayed more than 2 weeks after PAOO surgery. Case reports on PAOO are considered as weak evidence to support the advantages of this technique.[6]

Fig. 1: Clinical case depicting Wilckodontic procedure

Micro-invasive procedures

Corticision: It is one of the minimally invasive alternatives to create a surgical injury to the bone without flap reflection. In this technique, a reinforced scalpel, and a mallet is used to go through the gingiva and cortical bone, without raising flaps. This surgical

injury is deemed enough to induce the RAP effect and move the teeth rapidly during orthodontic treatment.[8] Although innovative, corticision has a few major drawbacks: The inability to graft soft or hard tissues during the procedure to correct inadequacies. Clinical effectiveness of corticision have been proven along with benefits such as eliminating the obvious disadvantages of previous techniques which included flap elevation that resulted in crestal bone resorption and bone dehiscence.[8]

Piezocision: Vercellotti and Podesta proposed the use of a piezo-electric knife instead of a high-speed surgical bur to decrease the surgical trauma and still achieve rapid tooth movement. It is a minimally invasive technique as the micro-incisons are limited to the buccal gingiva that allows the use of a piezoelectric knife to give osseous cuts to the buccal cortex and initiate the RAP without involving palatal or lingual cortex.[9] Because of its micrometric and selective cut, a piezoelectric device produces safe and precise osteotomies without osteonecrosis damage. It also has the advantage of allowing for hard-tissue or soft-tissue grafting via selective tunneling to correct gingival recessions or bone deficiencies in patients. This novel approach is leading to short orthodontic treatment time, minimal discomfort, and great patient acceptance, as well as enhanced, or stronger, periodontium. Because of the added grafting (bone and/or soft-tissue), the periodontium is much thicker buccally. Piezocision stimulates the alveolar bone turnover through increased osteoclasticactivity as early as 1-day and leads to RAP. It also allows to "bypass" the lag phase following the displacement phase and this forms the basis of rapid tooth movement compared to the conventional orthodontic treatment. The healing at the clinical level is much more predictable and much less painful. Therefore, the recovery is better and more acceptable to the patient. These physical modifications have proven to be beneficial in several ways: Increased stability of the clinical outcomes (less orthodontic relapse), increased scope of malocclusion correction (at times, avoiding orthognathic surgery), and reduced active orthodontic treatment time.[10]

Micro-osteoperforation: Performed using the PROPEL System, is a safe and effective micro-invasive technique to accelerate orthodontics by about 50–60% faster movement than traditional orthodontics alone.(Fig. 2) PROPEL can be completed chair-side in minutes and does not require any advanced training.[11] Unlike other systems, PROPEL is unique in that it can be targeted to specific teeth or quadrants rather than applied to the whole dentition at once in an uncontrolled fashion which may lead to anchorage issues. It also serves as a cost-effective alternative to implants in cases of adults with mutilated dentitions that often involves orthodontic closure of the edentulous region and with PROPEL, duration of treatment will be shortened making orthodontics an acceptable option. 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. Micro-osteo-perforation is a comfortable, and safe procedure to accelerate tooth movement, and significantly reduce the duration of orthodontic treatment.[11]

Fig. 2: Propel Device

Non-invasive Methods: Photo-bio-modulation or low-level laser therapy. It is one of the most promising approaches today. Laser light has been found to stimulate the proliferation of osteoclast, osteoblast, and fibroblasts, and thereby affect bone remodeling and accelerates tooth movement.[12] Low level laser therapy accelerates tooth movement by30–60%. Erbium laser reduces or maintains the pulpal temperature thus eliminating the side effects on pulp. In techniques where burs and piezoelectric devices are used, the physical contact between the instrument head, and tissue is usually a source of discomfort whereas lasers are non-contact. LASER cuts the bone with minimal thermal damage and have precise control of bone cutting. Recent studies shows that laser facilitated flapless corticotomy is a useful procedure to speed up treatment time and it eliminates the necessity of invasive flap surgery. Various studies have shown great success in accelerating tooth movement on use of low level laser therapy. An average increase in 30% rate of tooth movement and pains cores were also low with low intensity laser therapy. Animal experiments have shown that low-level laser can accelerate tooth movement. Furthermore, clinical trial attempts were made in which different intensities of laser were used and different results were obtained.[13]

The Biolux LED Device: The hard plastic case with sponge insulation in which the LED device was provided to each patient to lessen against impact damage. (Fig. 3) Each device was composed of a facemask with LED arrays, a power supply and a hand-held controller unit. Each face mask unit was positioned to ensure a firm and reproducible position on the face

with the LED arrays parallel to the occlusal plane of the patient. The LED array was positioned and programmed to target the root of the tooth undergoing retraction as well as the extraction space into which the tooth was being moved on only one side of the face.[1]

Fig. 3: Biolux Machine

AcceleDent: Recently, a product by the name AcceleDent has been introduced which makes use of the vibrations/micro-impulses to hasten tooth movement. (Fig. 4) This is a simple to use, hands free device which has a mouthpiece that is inserted around the existing braces and the activator is turned on for 20 min every day to generate small vibrations. It is a portable device that can be charged similar to any other electronic device. Research has shown that the tooth movement is accelerated by 106% during initial phase of treatment and up to 50% during subsequent phase of treatment, thus reducing the orthodontic treatment duration. However, as the system is newly introduced, further long-term research is required to prove its results.[14]

Fig. 4: Acceledent Machine

Pharmacological agents: Chemically produced PGE2 in human trials showed that the rate of distal retraction of canines was 1.6-fold faster than the control side. However, prostaglandin leads to a generalized increase in the inflammatory state and also causes root resorption. Research has shown that Vitamin D3 may be more effective in bone turn over rather than acceleration of tooth movement, as greater number of osteoblasts is seen on side where Vitamin D3 was injected. Vitamin D when injected in the periodontal ligament (PDL) increases the levels of lactate dehydrogenase and creatine phosphokinase enzymes.[3,15]

However, a recent prospective split mouth clinical trial carried out by Shetty et al. showed that the experimental teeth that received local injections of Vitamin D3 moved considerably slower than the matched control teeth. Locally, injected parathyroid hormone (PTH) was found to be more efficacious when compared to the systemically administered form and slow release application of PTH was seen to be more efficient than PTH in saline solution in causing acceleration of tooth movement in rats.[16]

Experiments on rats suggest significant effect of relaxin on tooth movement acceleration, however, similar studies on humans suggest exactly the opposite. Relaxin reduces PDL reorganization and mechanical strength of PDL, thereby it might contribute to reduction in the rate of relapse. All of these drugs have some or the other unwanted adverse effect. As of today, no drug exists that can safely accelerate orthodontic tooth movement.[16]

Magnets: Tengku BS 2008 used a Ni-Ti expansion spring on the 1st molar of Wistar rats, and applied a vibration of 60 Hz, 1 m/s^2. They stated that the rats that received the vibration showed increased orthodontic tooth movement.[17] In the sectioned samples, they showed increased RANKL expression in the fibroblasts and osteoclasts of the periodontal ligament of the rats that received vibration. Recently, a product by the name Acceledent has arrived at the market, which makes use of this technology. This device consists of an activator, which is the active part of the appliance that delivers the vibration impulses with a USB interface through which it can be connected to a computer to review the patient usage of the appliance, a mouthpiece that contacts the teeth. It is a portable device that can be charged similar to any other electronic device, and has to be worn for 20 minutes a day. Various case studies using this device have shown the treatment times to be reduced by upto 30-40%. Developed by Ortho Accel Technologies, Inc., Leader in Accelerated Orthodontics, AcceleDent Aura is a simple-to-use, hands-free device designed for faster orthodontic treatment with only 20 minutes daily use. AcceleDent Aura is approved by the United States Food and Drug Administration (FDA). It has been prescribed to thousands of patients worldwide, since its introduction in 2009. It is available only by prescription from your orthodontist. By inserting the mouthpiece fitted around your existing orthodontics and wearing the activator for 20 minutes everyday, AcceleDent Aura can speed up tooth movement

through the use of SoftPulse Technology. Faster tooth movement may decrease the duration of your orthodontic treatment and may help to make your orthodontics more comfortable.[17,18]

The Aevo System: For over 20 years, existing low-intensity pulsed ultrasound (LIPUS) therapies have been proven to accelerate the repair of long bone fractures. This proven history, along with the orthodontic challenge, inspired the development of the Aevo System™, a home-use orthodontic therapy. The patented 'Aevo System™' is also the most advanced therapeutic LIPUS system in the world. (Fig. 5) It consists of our Check & Adjust clinic software, versatile electronics, oral ultrasound gel, and our intra-oral transducer system. This safe, easy-to-use device is battery powered to allow for greater portability. It's also available in three models for customizable home treatment.[14,15]

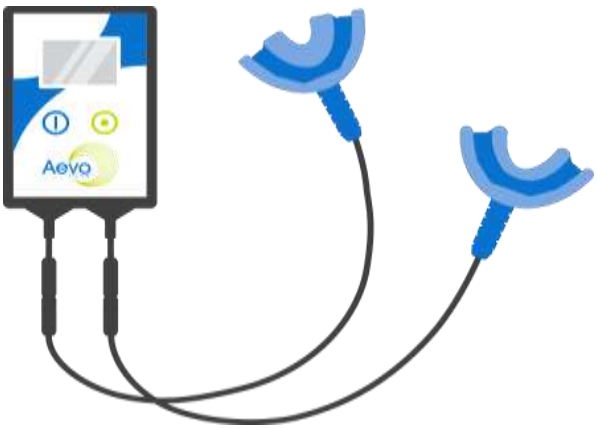

Fig. 5: Aevo Machine

Conclusion

Since long, orthodontic patients have been asking for shorter treatment times, and today, we do have methods that can accelerate orthodontic tooth movement safely. The current methods such as piezocision, micro-osteo-perforations, 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.

References

1. American Dental Association (2001). The Future of Dentistry, pg. 81. Retreived 7/12/2005 at http:// www.ada.org/prof/resources/topics/futuredent/ future_chap05_06.pdf.
2. Maurya RK, MP Prassanna. Changing face of orthodontics treatment- from braces to brace-less. Journal of Dentistry Defence Section 2016;11.1,21-27.
3. Teixeira CC, Khoo E, Tran J, Chartres I, Liu Y, Thant LM, et al. Cytokine expression and accelerated tooth movement. J Dent Res 2010;89:1135-41.
4. Kole H. Surgical operation on the alveolar ridge to correct occlusal abnormalities. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1959;12:515–29.
5. Wilcko WM, Wilcko MT, Bouquot JE, Ferguson DJ. Rapid orthodontics with alveolar reshaping: two case reports of decrowding. Int J Periodontics Restorative Dent. 2001;21:9–19.
6. Wilcko MT, Wilcko WM, Bissada NF. An evidence-based analysis of periodontally accelerated orthodontic and osteogenic techniques: A synthesis of scientific perspectives. Semin Orthod 2008;14:305-16.
7. Cruz DR, Kohara EK, Ribeiro MS, Weer NU. Effects of low intensity laser therapy on the orthodontic movement velocity of human teeth: A preliminary study. Lasers Surg Med 2004;35:117-20.
8. Park YG, Kang SG, Kim SJ. Accelerated tooth movement by Corticision as an osseous orthodontic paradigm. Kinki Tokai Kyosei Shika Gakkai Gakujyutsu Taikai, Sokai. 2006;48:6.
9. Vercellotti T, Podesta A. Orthodontic microsurgery: a new surgically guided technique for dental movement. Int J Periodontics Restorative Dent. 2007;27:325–331.
10. Dibart S, Sebaoun JD, Surmenian J. Piezocision: A minimally invasive, periodontally accelerated orthodontic tooth movement procedure. Compend Contin Educ Dent 2009;30:342-4.
11. Nicozisis J. Accelerated Orthodontics with Alveocentesis. Princeton Orthodontics. Clin Orthod. 2012;19:1–4.
12. Maurya RK, Gupta A, Singh H, Thakkar S, Mishra H. Effects of 'low light laser' and 'light emitting diode' mediated 'photo-bio-dynamic' therapy on clinical & biomechanical efficiency of orthodontic mini-implants- a randomized control trial. Journal of Clinical Orthodontics. In the press.
13. Doshi-Mehta G, Bhad-Patil WA. Efficacy of low-intensity laser therapy in reducing treatment time and orthodontic pain: A clinical investigation. Am J Orthod Dento facial Orthop 2012;141:289-97.
14. Shenava S, Krishna Nayak US, Bhaskar V, Nayak A. Accelerated orthodontics – A review. Int J Sci Study 2014;1:35-9.
15. Yamasaki K, Shibata Y, Imai S, Tani Y, Shibasaki Y, Fukuhara T. Clinical application of prostaglandin E1 (PGE1) upon orthodontic tooth movement. Am J Orthod. 1984;85:508-18.
16. Bartzela T, Türp JC, Motschall E, Maltha JC. Medication effects on the rate of orthodontic tooth movement: A systematic literature review. Am J Orthod Dentofacial Orthop 2009;135:16-26.
17. Tengku BS, Joseph BK, Harbrow D, Traverne AAR, Symons AL. Effect of Static Magnetic Field on Orthodontic Tooth Movement in the Rat. Eur J Orthod 2000;22:475-87.
18. Showkatbakhsh R, Jamilian A, Showkatbakhsh M. The effect of pulsed electromagnetic fields on the acceleration of tooth movement. World J Orthod. 2010;11:e52–e56.