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REVIEW ARTICLE

THE ACCELERATION OF TOOTH MOVEMENT: A REVIEW

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ABSTRACT

There is a rising influx of adult patients seeking orthodontic treatment in the recent era.20-25% of orthodontic patients are reported to be adults and this trend is likely to rise by leaps and bounds in near future in view of society becoming more esthetic and health conscious. Unfortunately, long orthodontic treatment time poses several disadvantages like higher predisposition to caries, gingival recession, root resorption and enamel demineralization. Hence it is imperative to explore and understand various aspects to reduce the orthodontic treatment time, to counteract the side effects of prolonged treatment and reduce the irritation among adult patients. This review discusses various ways to accelerate the orthodontic tooth movement and what are the most viable options amongst those. Also it emphasizes on the advantages & disadvantages posed by these different techniques. Biological, physical and surgical techniques were discussed along with their pros and cons. Prostaglandins, relaxin and vitamin D showed lesser promising use on humans, because most of the work done is on animals. Lower laser irradiation therapy was found to have more assuring results amongst the physical and mechanical ways. Surgical techniques though being most successful & widely used had the drawbacks of invasiveness & discomfort. Piezoincision is a less invasive surgical technique and hence has a lot of scope in future. Most of the methods discussed have been successfully proven to reduce treatment times by up to 70% .It was concluded that all these techniques offer efficacious results one way or the other as far as the acceleration of orthodontic tooth movement is concerned.

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INTRODUCTION

Crowding is one of the most common forms of malocclusion (Proffit *et al.,* 2007). It is one of the oldest types of dental disease originating as far back as 12,000 years ago. Orthodontists have been constantly developing tools and techniques to achieve the desired results both clinically and technically to resolve the malocclusions (Burgersdijk *et al.,* 1991). Orthodontic treatment is based on the premise 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 allow for structural alterations and contribute to the tooth movement. Conventionally, this process is slow and orthodontic treatment times can range anywhere between 12-48 months (Lerner, 2012). The long orthodontic treatment is one of the common challenging factors faced by the orthodontists and causes irritation among adult patients. A number of attempts have been made to create different approaches both pre-clinically and clinically in order to achieve quicker results, but still there are a lot of uncertainties and unanswered questions towards most of these techniques (Burgersdijk *et al.,* 1991). Orthodontic tooth movement occurs in the presence of a mechanical stimuli sequenced by remodeling of the alveolar bone and periodontal ligament (PDL). Bone remodeling is a process of both bone resorption on the pressure site and bone formation on the tension site (Krishnan *et al.,* 2012). Orthodontic tooth movement can be controlled by the magnitude of the applied force and the biological responses from the PDL. The force applied on the teeth will cause changes in the microenvironment around the PDL due to alterations of blood flow, leading to the secretion of chemical mediators responsible for orthodontic tooth movement. There have been studies done to accelerate these chemical responses to fasten the tooth movement, which would reduce the treatment time by all means. Different modes have been introduced to do so. Most attempts can broadly be categorized into biological, physical, biomechanical, and surgical approaches (Lerner, 2012).

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METHODS TO ACCELERATE TOOTH MOVEMENT

Biological factors and their effect on tooth movement

Prostaglandins

Prostaglandins (PGs) are inflammatory mediators and paracrine hormones that act on nearby cells. They stimulate bone resorption by increasing directly the number of osteoclasts. In vivo and in vitro experiments were conducted to show clearly the relation between PGs, applied forces, and the acceleration of tooth movement (Krishnan and Davidovitch, 2006) (Bartzela *et al.,* 2009). Administration of PGE 1 sub mucosal injections in humans in the canine retraction areas for a period of 3 weeks increased the rate of tooth movement by 1.6 folds compared to the site that did not receive any injection. No adverse effects either in the gum tissue or the alveolar bone were found. Only mild pain related to the dental movement was observed (Yamasaki *et al.,* 1984). 1 g of PGE 1 injected for three days (3 g in total), using lidocaine as a vehicle substance in the distal buccal area of canines increased the rate of retraction with NiTi open coil spring in the orthodontic patients (Patil *et al.,* 2005). However, root resorption was very clearly related to the different concentrations and number of injections given. It has also been shown that the administration of PGE 2 in the presence of calcium stabilizes root resorption while accelerating tooth movement in rats (Seifi *et al.,* 2003).

Cytokines

IL-1, IL-2, IL-3, IL-6, IL-8 & tumor necrosis factors have been found to play a role in bone remodeling by stimulating the osteoclast function in bone remodeling in cats (Saito *et al.,* 1991). Cytokines stimulate osteoclastic function through their receptors on osteoclasts (Andrade *et al.,* 2012). Other cytokines involved in tooth movement are RANKL; a membrane bound protein on the osteoblasts that binds to the RANK on the osteoblasts and causes osteoclastogenesis (Drugarin *et al.,* 2003). Experiments are done on the rats which showed the transfer of periodontal tissue caused the prolonged gene expression for the enhancement of the osteoclastogenesis and acceleration of tooth movement (Kanzaki *et al.,* 2006). None of this is yet tried in humans.

Vitamin D3

1,25 dihydroxycholecalciferol is a hormonal form of vitamin D and plays an important role in calcium homeostasis with calcitonin and parathyroid hormone (PTH). Experimentally it is known to increase the amount of osteoclasts on the pressure side of tooth movement (Collins and Sinclair, 1988). A systemic dose of calcitrol supplement (0.25 μg), when administered accelerates canine retraction movement in rats over 60 days as compared to a control group (Blanco *et al.,* 2001). Injections of vitamin D metabolite on the PDL of cats for several weeks resulted in accelerated tooth movement at 60% more than the control group due to the increased osteoclastic activity on the pressure site as detected histologically (Collins and Sinclair, 1988). A comparison between local injection of vitamin D and PGEs on two different groups of rats are also investigated. It is found that there is no significant difference in acceleration between the two groups. However, the number of osteoblasts on the pressure side injected by vitamin D was greater than on the PGE 2 side. This indicates that vitamin D may be more effective in bone turnover (Kale *et al.,* 2004).

Relaxin

Relaxin has been publicized to increase the collagen in the tension site and decreases it in compression site during orthodontic movement (Nicozicis *et al.,* 2000). Administration of human relaxin may accelerate the early phase of tooth movement (Liu *et al.,* 2005).In randomized clinical trial on humans, weekly injections of 50 μg of relaxin for 8 weeks did not show any significant difference in the tooth movement (McGrray *et al.,* 2012). However, it is believed that remodeling of PDL by relaxin might reduce the rate of relapse after orthodontic treatment (Masella and Meister, 2006).The exact mechanism of how relaxin works on tooth movement is not yet fully understood though (Table 1).

Table 1. Biological factors responsible for tooth movement acceleration

Biological factor	Experimental model	Effect on tooth movement	Author
PGE 1	Humans	Increased	Yamasaki et al
PGE 1	Humans	Increased	Patil et al
PGE 2	Rats	Increased	Seifi et al
Cytokines	Cats	Increased	Saito et al
Cytokines	Rats	Increased	Kanzaki et al
Vit D3	Rats	Increased	Blanco et al
Vit D3	Rats	More bone turnover	Kale et al
Relaxin	Humans	Increased	Liu et al
Relaxin	Humans	No effect	McGrray et al
Relaxin	Humans	Reduced relapse	Masella

Physical factors and their effect on tooth movement

This includes some device assisted physical therapies (Kaou *et al.,* 2010).The concept of using physical approaches came from the idea that applying orthodontic forces causes bone bending which develops bioelectrical potential. The cyclic impulses generated by these devices would generate same bioelectric field. The concave site will be negatively charged attracting osteoblasts and the convex site will be positively charged attracting osteoclasts (Zengo *et al.,* 1974).

Direct Current Application

A direct current on pressure and tension site of 7 A in magnitudes was applied through electrodes in the animal experimental models to generate the response. The bone remodeling was observed and there was acceleration in tooth movement (Davidovitch *et al.,* 1980). These modalities have also been shown to reduce relapse, pain and root resorption caused due to orthodontic forces (Shailesh *et al.,* 2014).

Cyclic forces

The principal behind the use of cyclic vibratory method is to place light alternating forces on the teeth via mechanical radiations (Kau *et al.,* 2010). A cyclic device was used to produce the vibration impulses of 20-30 Hz for 20 minutes each day in human teeth. These vibrations produced the remodeling activity and created tooth movement at the rate of 2-3 mm/month. These devices are portable, that can be charged similar to any other electronic device. Various case

studies using this device have shown the treatment times to be reduced by up to 30-40 % (Liou, 2010).

Pulsed electromagnetic field

Pulsed electromagnetic field was capable of accelerating orthodontic tooth movement in rats. The canines on one side which required retraction were exposed to a pulsed electromagnetic field (PEMF). A circuit and a watch battery were used to generate the PEMF (1 Hz).It was reported that the cumulative distance moved by the canine was greater on the pulsed side compared to the control group (Showkatbakhsh *et al.,* 2010).

Low level laser irradiation/Low level laser therapy

(LLLT) is also known as "soft laser therapy" and bio-stimulation. Laser has a bio stimulatory effect on bone regeneration and also stimulates bone regeneration after bone fractures at extraction site (Saito and Shimizu, 1997). The most common and effective energy input with LLLI was the interval of 0.2–2.2J per point/2–8J per tooth at a frequency of application 1–5 days per month to accelerate the orthodontic movement in class III patients (Kesser and Dibart, 2011). In an experimental study 10 g of orthodontic force was applied to rat molars to cause tooth movement. After 12 days in the laser irradiation group, the amount of tooth movement and rate of cellular proliferation in the tension side and the number of osteoclasts in the pressure side were significantly greater than that of the non-irradiation group (Kawasaki and Shimizu, 2000). The first study carried out on humans to assess the effect of low-intensity laser therapy on orthodontic tooth movement showed that the irradiated canines were retracted at a rate 34% greater than the non-irradiated group over 60 days (Cruz *et al.,* 2004). Ga-Al-As laser was used during the retraction phase in human experimental model. Canines were irradiated on their buccal and palatal sides with 809 nm and 100 mW for 40 seconds; the total dose to the right upper and lower canines was 8 J, the left side was used as a control.

Table 2. Physical factors responsible for tooth movement acceleration

Physical factor	Experimental model	Effect on tooth movement	Author
Direct Current	Animals	Increased	Davidovitch et al
Cyclic Forces	Humans	Increased	Liou et al
Pulsed electromagnetic	Rats	Increased	Showkatbaksh et al
LLLI	Humans	Increased	Kesser
LLLI	Rats	Increased	Kawasaki et al
LLLI	Humans	Increased	Cruz et al
LLLI	Humans	Increased	Youssef et al

The laser was applied using intervals of 0, 3, 7 and 14 days. The results showed a significant increase in rate of movement for the irradiated canines when compared to the control. Pain level was also reduced in the irradiated group (Youssef *et al.,* 2008). Various studies on low level laser therapy have shown orthodontic tooth movement to be increased by 30-60%. LLLI seems to be efficient; also it is a method with simple application, painless, does not present side effects, and has very few contraindications. However to achieve positive results, it is necessary to use the correct dosimetry, because LLLI is dose dependent (Doshi and Bhad, 2012). (Table 2)

Surgical techniques for accelerating tooth movement

The idea of surgical acceleration came into being after the Regional Acceleratory Phenomena, which is local response to a noxious stimulus (Frost 1983). It is described as a process by which tissue forms 2-10 times faster than the normal regional regeneration process through the enhancement of various healing stages. The bone is irritated surgically, an inflammation cascade is initiated which causes increased osteoclastogenesis, hence causing faster tooth movement. (Periodontally Accelerated Osteogenic Orthodontics) (Wilcko *et al.,* 2008).

Corticotomy and Osteotomy

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 (Liou *et al.,* 2011). It was first tried in orthodontics by Kole. (Kole, 1959). Osteotomy is when a segment of the bone is cut into the medullary bone, separated and then moved as a unit. The phenomenon of regeneration is same as of corticotomy (Lee *et al.,* 2008). Corticotomy was introduced as a minimally invasive technique to surgically injure the bone without flap elevation (Kim *et al.,* 2008). It involves reinforced scalpel and mallet to go through the gingiva and cortical bone. This technique induces RAP effect. Despite it being a minimally invasive procedure, few experimental studies showed some drawbacks such as; inability to place grafts, and the malleting procedure was shown to cause dizziness after surgery (Clinicas, 2013). Corticotomy procedure causes minimal changes in the periodontal attachment apparatus. The orthodontic appliance is activated immediately upon wound closure (Gantes *et al.,* 1990). Corticotomy-assisted canines showed a reduction of 28 - 33% in treatment time (Fischer 2007). Another added advantage of corticotomy is that bone can be augmented; thereby preventing periodontal defects, which might arise, as a result of thin alveolar bone (Frost, 1983). Some of the reported disadvantages of this procedure are high morbidity, invasive, chances of damage to adjacent vital structures, post-operative pain, swelling, chances of infection, avascular necrosis and low acceptance by the patient (Shaleish*et al.,* 2014).

Piezocision

To overcome the disadvantages of other corticotomy techniques, a minimally invasive technique was introduced consisting of a flapless procedure combining piezo surgical cortical micro-incisions with selective tunneling that allows for bone or soft-tissue grafting. Due to their small size and precision, piezoelectric cutting inserts precise osteotomies without the risk of osteonecrosis. The technique is to remove the lingual flap by performing only vestibular incisions, but

the elevation of a flap prior to the corticotomy is maintained, this relatively reduces surgical time and postoperative discomfort (Diabart *et al.,* 2009). Piezocision was compared with other short treatment therapies and it was found that piezoincison is an effective therapy to reduce treatment time when compared to treatments such as invisalign (Sebaoun *et al.,* 2011). This technique poses great advantages of being minimally invasive and better patient acceptance. However one of the reported disadvantage is risk of root damage (Jorge *et al.,* 2013).

Dentoalveolar distraction/Interseptal Alveolar Surgery

Dentoalveolar distraction (DAD) also known as interseptal alveolar surgery is performed by making monocortical perforations on alveolar bones around the canines, followed by distracting the canine using distractors (Kişnişci *et al.,* 2002). It is based on the concept of the distraction osteogenesis where the jaw bones are fractured intentionally to promote the regional acceleratory phenomena for rapid bone movement (Kharker and Kotrashetti, 2010).

Table 3. Surgical factors responsible for tooth movement acceleration

Surgical factor	Experimental model	Effect on tooth movement	Author
Corticotomy	Humans	Increased	Liou *et al.*
Corticotomy	Humans	Increased	Kim *et al.*
Corticotomy	Humans	Increased	Gantes *et al.*
Corticotomy	Humans	Increased	Fischer
Piezoincison	Humans	Increased	Diabart *et al.*
Piezoincison	Humans	Increased	Sebaoun *et al.*
Detoalveolar Distraction	Humans	Increased	Akhare *et al.*
Detoalveolar Distraction	Humans	Increased	Iseri *et al.*
Detoalveolar Distraction	Humans	Increased	Kurt *et al.*
Detoalveolar Distraction	Humans	Increased	Liou *et al.*
Detoalveolar Distraction	Humans	Increased but declined to same level	Gurgan

Canine retraction is a movement very heavy on anchorage. The longer the time spent on retraction the more are the chances of anchorage loss. Dentoalveolar distraction has been used to accelerate the canine retraction. Osteotomies surrounding the canines are performed to achieve rapid movement of the canines within the dentoalveolar segment, in compliance with distraction osteogenesis principles. In the experimental studies on humans the first maxillary premolars were extracted and the canines were retracted in the extraction space through the dentoalveolar distraction surgical procedure. A custom-made intraoral, rigid, tooth-borne distraction device was put in place. The canines were moved rapidly into the extraction sites in 8 to 14 days, at a rate of 0.8 mm per day and full retraction of the canines was achieved in a mean time of 10.05 (± 2.01) days (Akhare *et al.,* 2011). In other experimental studies on humans the amount of canine retraction was 7.5 mm in 12 days at a rate of 0.625 mm per day (Iseri *et al.,* 2005). DAD has been found successful for canine retraction in severe class II malocclusions with overjets of more than 9 mm. Rigid, tooth-borne intraoral distraction devices usually custom made to cater to each patient's individual needs are used for rapid canine retraction (Kurt *et al.,* 2010). DAD is found to reduce treatment time by 50%. And it is feasible in dental practice (Liou and Huang 1998). However it poses some disadvantages in the form of invasiveness and aggressiveness. It's a bit costly compared to the other options available. The acceleration in some of the studies was seen for few months and then declined to the same level (Gurgan *et al.,* 2005). (Table 3)

Conclusion

The biological stimuli have been extensively used in animals but their human trials are still new and require more exploration. Also they involve injections that can be painful and discomforting for the patients. Also the long term systemic effects of these substances are not known. Amongst the physical factors, low level laser irradiation seems to be most promising. It is very easy to administer and had an added effect of pain reduction which has double ended benefit for the patients. The surgical techniques have the most of the human trials and also show very favorable and long term effects adding on to the stability and retention of the orthodontic therapy. However the invasiveness and cost of these might make it little less viable option for the patients. Piezo incision on the other hand is the least discomforting amongst all the surgical procedures and this makes it a more commonly used procedure in future. Tooth acceleration phenomenon is still a relatively new horizon and researchers have yet to seek a single most ideal and prudent technique for their orthodontic patient. Yet at the same time any of these techniques once adapted depending upon clinician's choice and patient's preference; can prove to be immensely beneficial in reducing orthodontic treatment time. This is a giant leap in the field of orthodontics.

REFERENCES

Akhare, P.J., Daga, A.M. and Shilpa, P. 2011. Rapid canine retraction and orthodontic treatment with dentoalveolar distraction osteogensis. *J Clin Diagnostic Res*. 7:1473–1477.

Andrade, I., Taddei, S.R. and Souza, P. 2012. Inflammation and tooth movement: the role of cytokines, chemokines and growth factors. Semin in Orthod, 18(4):257-269.

Bartzela, T., Türp, J. C., Motschall, E. and Maltha, J.C. 2009. Medication effects on the rate of orthodontic tooth movement: a systematic literature review. *Am J Orthod and Dentofacial Orthop.*, 135(1): 16-26.

Blanco, J.F., Diaz, R., Gross, H. and Rodríguez, N. 2001. Efecto de la administración sistémica del 1,25 Dihidrxicolecalciferol sobre la velocidad del movimiento ortodóncico en humanos. Estudio Clínico. Revista Odontos, 8:13–21.

Burgersdijik, R.C.W., Truin, G.J., Frankenmolen, F., Kalsbeek, H. and Mulder, J. 1991. Malocclusion and orthodontic treatment need of 15-74years old Dutch adults. *Community Dent Oral Epidemiol*.,19:64-67.

Clínicas, P. E. 2013. Rapid Orthodontics with Flapless Piezoelectric Corticotomies: First Clinical Experiences. *Int. J. Odontostomat*. 7(1): 79-85.

Collins, M.K. and Sinclair, P.M. 1988. The local use of vitamin D to increase the rate of orthodontic tooth movement. *Am J Orthod Dentofacial Orthop.*, 94(4): 278–284.

Cruz, D.R., Kohara, E.K., Ribeiro, M.S. and Wetter, N.U. 2004. Effects of low-intensity laser therapy on the orthodontic movement velocity of human teeth: a preliminary study. Lasers Surg. Med, 35:614–622.

Davidovitch, Z., Finkelson, M.D., Steigman, S., Shanfeld, J.L., Montgomery, P.C. and Korostoff, E. 1980. Electric currents, bone remodeling, and orthodontic tooth movement. II. Increase in rate of tooth movement and periodontal cyclic nucleotide levels by combined force and electric current. *Am J Orthod.*, 77(1): 33–47.

Dibart S., Sebaoun, J.D. and Surmenian, J. 2009. Piezocision: a minimally invasive, periodontally acceleratedorthodontic tooth movement procedure. Compend Contin Educ Dent, 30:342–350.

Doshi, M. G. and Bhad, W.A. 2012. Efficacy of low-intensity laser therapy in reducing treatment time and orthodontic pain: a clinical investigation. *Am Journal of Orthod and Dentofacial Orthop.*, 141(3): 289-297.

Drugarin, D.D.M., Negru, S. and Cioace, R. 2003. RANKL/RANK/OPG molecular complex control factors in bone remodeling. TMJ. 53:296–302.

Fischer, T.J. 2007. Orthodontic treatment acceleration with corticotomy-assisted exposure of palatally impacted canines. Angle Orthod, 77:417–420.

Frost, H.M. 1983. The regional acceleratory phenomenon: a review. *Henry Ford Hospital Medical Journal.*, 31(1):3.

Gantes, B., Rathbun, E. and Anholm, M. 1990. Effects on the periodontium following corticotomy-facilitated orthodontics: case reports. *J Periodontol.*, 61:234–238.

Gürgan, C. A., İşeri, H. and Kişnişçi, R. 2005. Alterations in gingival dimensions following rapid canine retraction using dentoalveolar distraction osteogenesis. *Eur J Orthod.*, 27:324–332.

Işeri H., Kişnişci, R., Bzizi, N. and Tüz, H. 2005. Rapid canine retraction and orthodontictreatment with dentoalveolar distraction osteogenesis. *Am J Orthod Dentofacial Orthop.*, 127:533–554.

Jorge, J. , Julio, M. and Roberto, A. 2013. Rapid Orthodontics with Flapless Piezoelectric Corticotomies: First Clinical Experiences, *Int. J. Odontostomat.*, 7(1).

Kale, S., Kocadereli. I., Atilla, P. and Asan, E. 2004. Comparison of the effects of 1,25 dihydroxycholecalciferol and prostaglandin E2 on orthodontic tooth movement. *Am J Orthod Dentofacial Orthop.*, 125(5): 607–614.

Kanzaki, H., Chiba, M., Arai, K., Takahashi, I., Haruyama, N., Nishimura, M. and Mitani, H. 2006. Local RANKL gene transfer to the periodontal tissue accelerates orthodontic tooth movement**.** Gene Ther, 13(8)**:** 678-685.

Kau, C.H., Jennifer, T.N. and Jeryl, D. 2010. The clinical evaluation of a novel cyclical-force generating device in orthodontics. *Orthodontic PracticeUS*, 1:43-44.

Kau, C.H., Nguyen, J.T. and English, J.D. 2010. The clinical evaluation of a novel cyclical force generating device in orthodontics. *Orthod Prac US.*, 1:10–15.

Kawasaki, K. and Shimizu, N. 2000. Effects of low-energy laser irradiation on bone remodeling during experimental tooth movement in rats. Lasers Surg Med, 26(3):282-291.

Kesser, E.I. and Dibart, S. 2011. Piezocision-assisted Invisalign treatment. *Compend Contin Educ Dent.*, 32:46–51.

Kharkar, V.R. and Kotrashetti, S.M. 2010. Transport dentoalveolar distraction osteogenesis-assisted rapid orthodontic canine retraction. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.*, 109:687–693.

Kim, D.H., Park, Y.G. and Kang, S.G. 2008. The effects of electrical current from a micro-electrical device on tooth movement. *Korean J Orthod.*, 38:337–346.

Kişnişci, R.S., Işeri, H. and Tüz, H.H. 2002. Dentoalveolar distraction osteogenesis for rapid orthodontic canine retraction. *J Oral Maxillofac Surg*., 60:389–394.

Kole, H.1959.Surgical operations on the alveolar ridge to correct occlusal abnormalities. *Oral Surg. Oral Med. Oral Pathol.*, 12:413–420.

Krishnan, V.and Davidovitch, Z. 2006. The effect of drugs on orthodontic tooth movement. Orthod Craniofac Res, 9(4): 163– 171.

Krishnan, V., Nair, S.V., Ranjith, A. and Davidovitch, C. 2012.Research in tooth biology: The current status. Semin in Orthod, 18(4)308-316.

Kurt, G., Işeri, H. and Kişnişci, R. 2010. Rapid tooth movement and orthodontic treatment using dentoalveolar distraction. Long-term (5 years) follow-up of a Class II case. Angle Orthod, 80:597–606.

Lee, W., Karapetyan, G., Moats, R., Yamashita, D.D., Moon, H.B., Ferguson, D.J. and Yen, S.2008. Corticotomy-/osteotomy-assisted tooth movement. *J Dent Res*., 87(9):861–867.

Lerner, U.H. 2012. Osteoblasts, osteoclasts and osteocytes: Unveiling their intimate associated responses to applied orthodontic forces. *Semin in Orthod.*, 18(4): 237-248.

Liu, D. 2010. Acceleration of Orthodontic tooth movement by mechanical vibration. AADR Annual meeting Washington D.C.

Liou. E.J., Chen, P.H., Wang, Y.C., Yu, C.C., Huang, C.S. and Chen, Y.R.2011. Surgery-first accelerated orthognathic surgery: orthodontic guidelines and setup for model surgery. *J Oral Maxillofac Surg*., 69:771–780.

Liou, E. J. W. and Huang, C.S .1998. Rapid canine retraction through distraction of the periodontal ligament. *Am J Orthod Dentofac Orthop*., 114:372–382.

Liu, Z.J., King, G.J., Gu, G.M., Shin, J.Y. and Stewart, D.R.2005 Does human relaxin accelerate orthodontic tooth movement in rats? *Ann N Y Acad Sci.*, 10(41): 388–394.

Masella, R.S. and Meister, M. 2006. Current concepts in the biology of orthodontic tooth movement. *Am J Orthod Dentofacial Orthop*., 129(4): 458–468.

McGorray, S.P., Dolce, C., Kramer, S., Stewart, D. and Wheeler, T.T. 2012. A randomized, placebo-controlled clinical trial on the effects of recombinant human relaxin on tooth movement and short-term stability. *Am J Orthod Dentofacial Orthop.*, 141(2): 196–203.

Nicozisis, J.L., Nah-Cederquist, H.D. and Tuncay, O.C. 2000. Relaxin affects the dentofacial sutural tissues. *Clin Orthod Res.*, 3(4): 192 –201.

Patil, A., Keluskar, K.M. and Gaitonde, S.D. 2005. The clinical application of Prostaglandin E1 on orthodontic movement-A clinical trial. *J Ind Ortho Soc*., 38:91–98.

Proffit, W.R., Field, H.W. Jr and Sarver, D.M. 2007. Contemporary Orthodontics. 4th ed. St. Louis, MO: Mosby Elsevier, 331-340.

Saito, M., Saito, S., Ngan, P.W., Shanfeld, J. and Davidovitch, Z.1991. Interleukin 1 beta and prostaglandin E are involved in the response of periodontal cells to mechanical stress in vivo and in vitro. *Am J Orthod Dentofacial Orthop.*, 99 (3): 226–240.

Saito, S. and Shimizu, N. 1997. Stimulatory effects of low power laser irradiation on bone regeneration in midpalatal suture during expansion in the rat. Am J Orthod Dentofacial Orthop, 111(5): 525-532.

Sebaoun, J.D., Surmenian, J. and Dibart, S. 2011. Accelerated orthodontic treatment with piezocision: a mini-invasive alternative to conventional corticotomie. Orthod Fr, 82:311–319.

Seifi, M., Eslami, B. and Saffar, A.S. 2003. The effect of prostaglandin E2 and calcium gluconate on orthodontic tooth movement and root resorption in rats. *Eur J Orthod*., 25(2): 199–204.

Shailesh, S., Vivek, B. and Arjun, N.2014. Accelerated Orthodontics – A Review, International Journal of Scientific Study, 1(5): 35-40.

Showkatbakhsh, R., Jamilian, A. and Showkatbakhsh, M. 2010. The effect of pulsed electromagnetic fields on the acceleration of tooth movement. *World J Orthod*., 11:52–56.

Wilcko, M.T., Wilko, W.M. and Bissada, N.F. 2008. An evidence-based analysis of periodontally accelerated orthodontic and osteogenic techniques: a synthesis of scientific perspective. *Seminars Orthod*., 14:305–316.

Yamasaki, K., Shibata, Y. and Imai, S.1984.Clinical application of prostaglandin E1 (PGE1) upon orthodontic tooth movement. *Am J Orthod.*, 85:508–518.

Youssef, M., Ashkar, S., Hamade, E., Gutknecht, N., Lampert, F. and Mir, M. 2008. The effect of low-level laser therapy during orthodontic movement: a preliminary study. Lasers Med Sci, 23:27–33.

Zengo, A.N., Bassett, C.A., Pawluk, R.J. and Prountzos, G. 1974. In vivo bioelectric potentials in the dentoalveolar complex. *Am J Orthod*., 66(2): 130–139.

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