Review Article

Fast track orthodontics: A review on methods of accelerating orthodontic treatment

ABSTRACT

Orthodontic treatment is, possibly, in terms of duration extent, the lengthiest dental procedure performed. There will be an increased favorable attitude for orthodontic treatment if the duration of the orthodontic treatment is reduced. Unfortunately, long-term orthodontic treatment also poses several disadvantages like a higher predisposition to dental caries, gingival recession, and root resorption. Quickening orthodontic tooth movement (OTM), i.e., accelerating, can remarkably decrease treatment time and side effects. Orthodontic treatment comprises the response of the tissues surrounding the tooth on which the force is being applied that happens on a cellular, mechanical level, and chemical. So, to improve the body's response to these orthodontic forces, various ways were found to accelerate the treatment, such as surgical methods (corticotomy, piezosurgery, etc.), mechanical/physical stimulation methods (vibration, lasers), drugs, etc., Hence, this review captures the current knowledge on accelerated OTM.

Keywords: Accelerated orthodontics, fast orthodontics, orthodontic treatment

INTRODUCTION

Orthodontic treatment in the present day requires meeting the demands of creating functional harmony in occlusion and improving the aesthetic outlook. We live in a fast-paced world where the treatment duration has made the field of orthodontic treatment revolve around it. However, a puzzling challenge that has not been completely solved in clinical orthodontics is the prolonged treatment time (on an average 2–3 years).[1] Overcoming this challenge will dramatically improve the quality of orthodontic care and motivate more people towards the concept of orthodontic treatment. Lengthy orthodontic treatment prompts many patients, especially adults, to either avoid treatment or to seek shorter alternative solutions with compromised results.[1] Thus, there has been increased search for techniques that accelerates the orthodontic tooth movement (OTM) without compromising the treatment outcome is an active area of research in orthodontics today.

OTM occurs due to mechanical stimuli sequenced by remodeling of the alveolar bone and periodontal ligament (PDL). Bone remodeling is a process of bone formation on the tension site and bone resorption on the pressure site. OTM can be regulated by the magnitude of the applied force and the biological responses from the PDL. Changes in the environment around the PDL due to alterations of blood flow are caused by force applied on teeth and lead to the release of different inflammatory mediators such as growth factors, neurotransmitters, cytokines, colony-stimulating factors, and arachidonic acid metabolites. Due to these secretions, remodeling of the bone occurs [Figure 1].[2,3] The purpose of this article is to review the various methods of accelerated OTM and their clinical applicability.

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Considering the above factors, the following methods were introduced to accelerate the tooth movement and thus shorten the duration of treatment time. They are broadly classified into [Table 1]:

1. Invasive methods
2. Non-invasive.

CORTICOTOMY

L. C. Bryan in 1893 proved that Corticotomy-facilitated tooth movement was indeed possible and was the first one to describe it. The conventional corticotomy procedure involves micromotor usage for executing the corticotomy cuts under continuous irrigation after elevating a full thickness of the mucoperiosteal flaps, which may either be on the buccal and lingual segment. Sometimes when the augmentation of bone is needed, graft placement is also advised along with the corticotomy cuts. Heinrick Köle's combined radicular corticotomy/supraapical osteotomy technique, which was first described in 1959, still remains popular as the currently used corticotomy procedures, which may be modified are still based on the same Heinrick Köle's ideology.[4]

Advantages

- It has been proven successful by many authors to accelerate tooth movement
- Bone can be augmented, thus preventing periodontal defects, which might arise due to thin alveolar bone.

Disadvantages

- High morbidity associated with the procedure
- Invasive procedure
- Chances of damage to adjacent vital structures
- Postoperative pain, swelling, chances of infection, avascular necrosis
- Low acceptance by the patient.

WILCKODONTICS

Wilcko reported in 2001 that the acceleration of tooth movement is not due to the bony block movement as postulated by Kole.[5] Instead, bone remodeling at the surgical site was a process called the regional acceleratory phenomenon (RAP). Wilcko *et al.* described that corticotomized patients clearly showed a transient localized demineralization-remineralization process consistent with the accelerated wound-healing pattern RAP as observed on a surface-computed tomographic evaluation.[6] He developed and patented techniques called accelerated oestrogenic Orthodontics (AOO) and periodontal AOO (PAOO). RAP was improved by adding bio-absorbable grafting material over the injured bone to boost healing. This technique has shown to have postoperative stability and improved retention, but more studies are still needed to be done. The main idea on which corticotomy works is the intentional induction of the acute inflammatory process leading to increased levels of inflammatory mediators such as prostaglandins (PGs) and cytokines, which in turn increases the rate of tooth movement.[6]

CLINICAL CONSIDERATIONS OF REGIONAL ACCELERATORY PHENOMENON

Clinical indications, according to the Wilcko brothers are:[6]

a. To accelerate or fasten corrective OTM
b. To facilitate the mechanically challenging orthodontic movements,
c. To facilitate correction of moderate to severe skeletal malocclusions.

PAOO is contraindicated in certain conditions such as:

a. In patients with active periodontal disease,
b. Inadequately performed endodontic treatment,
c. Patients with a history of prolonged corticosteroid usage,
d. Patients on medication that interfere with bone metabolisms such as bisphosphonates or nonsteroidal anti-inflammatory drugs.

Advantages

a. It has been proven successful by many authors to accelerate tooth movement
b. Bone can be augmented, thereby preventing periodontal defects, which might arise due to thin alveolar bone.

Disadvantages

- High morbidity associated with the procedure
- Invasive procedure
- Chances of damage to adjacent vital structures
- Postoperative pain, swelling, chances of infection, vascular necrosis
- Low acceptance by the patient.

PIEZOCISION AND PIEZOPUNCTURE

Reflecting the full thickness flap for corticotomy was considered too invasive to overcome this drawback, Dibart *et al.,* in 2009, presented a flapless method of corticotomy using piezosurgery. The surgery was performed 1 week after placement of orthodontic appliance under local anesthesia in the technique described by them. Gingival vertical incisions, only buccally, were made below the interdental papilla in the attached gingiva using a No. 15 scalpel [Figure 2a]. This procedure's main objective was to create an incision deep

enough to pass through the periosteum and contact the cortical bone. A BS1 insert Piezotome was used to perform the corticotomy cuts through the incisions made to a depth of 3 mm [Figure 2b]. Once again, if bone reinforcement is required, it can be done by using an elevator at the areas requiring bone augmentation. The elevator is inserted between the incisions to create "tunnels" to establish sufficient space to accept the graft material. Suturing is not usually required unless the graft materials need to be stabilized. The patient is placed on an antibiotic, mouthwash regimen.[7] Piezopuncture also gave similar results but with a lesser insult to the bone and surrounding tissue.[8]

Advantages

- Minimally invasive
- Better patient acceptance
- Disadvantages
- Risk of root damage, as incisions and corticotomies are "blindly" done.

MICROOSTEOPERFORATIONS

To achieve an orthodontic movement quickly enough with minimum invasion in the bone's surrounding tissues, Propel Orthodontics introduced a device called "Propel." They puncture the bone to speed up the tooth movement, as various studies have already proven the positive outcome of micro-osteoperforation [Figure 3a]. They called this process Alveocentesis, in the literal sense. Micro-osteoperforations stimulate the expression of inflammatory markers, leading to an increase in osteoclastic activity, leading to an increased tooth movement rate. This technique requires a ready-to-use sterile disposable device [Figure 3b]. Indicating arrow on the driver's body and adjustable depth dial is present on the device, which can be positioned to 0 mm, 3 mm, 5 mm, and 7 mm of tip depth, depending on the operation area.[4]

DENTOALVEOLAR DISTRACTION

Distraction osteogenesis is a procedure in which the new bone grows by mechanical stretching of the preexisting bone tissue. The technique of distraction osteogenesis involves the mechanical extension of the reparative bone tissue by a distraction device through an osteotomy or corticotomy site. With this technique, new bone is generated in the gap of osteotomy or corticotomy at the approximate rate of 1 mm per day. This has been used for lengthening mandibles than moving individual teeth. Liou and Huang in 1998 found that when the distractor was used in between premolars, rates of tooth movement of up to 1.2 mm/week was achieved.[9] Işeri *et al*., in a study, said that they achieved tooth movement of 0.8 mm per day by moving a canine and its associated block of bone into a premolar extraction space through a distractor appliance.[10] There were no adverse effects such as periodontal problems, ankylosis, and root resorption.[3]

LASERS AND BIOMODULATION

It is well known that low-intensity laser therapy (LILT) can lessen discomfort and pain due to trauma or even by the forces applied on the teeth by a biostimulation effect in the irradiated area. This stimulation might also increase bone repair, which can be considered a way to accelerate postsurgery, orthopedics, or implant procedures [Figure 4]. After low-level laser therapy (LLLT), it observed *in vivo* and *in vitro* that there was an increased osteoblastic and osteoclastic activity.[11] The mechanism involved in the speeding up of tooth movement is the activation of cytochrome C and by producing ATP, as shown in that low-energy laser irradiation enhanced the rate of tooth movement through RANK/RANKL and the macrophage colony-stimulating factor and its receptor expression. Saito and Shimizu studied the impact of LILT on the expansion of mid-palatal sutures in rats, comparing the bone regeneration obtained with and without laser treatment. Their results showed that the therapeutic effects of laser are dependent on the total dosage, the frequency, and the duration of the treatment. Their laser-irradiated group showed 20%–40% better results when compared to the control group.[12] In another study, Kawasaki and Shimizu showed that the orthodontic movement of laser irradiated rats' teeth was 30% quicker than the nonirradiated rats due to acceleration of bone formation as a result of the cellular stimulation promoted by LILT.[13] Bio-stimulation effects on bone repair are directly dependent on the dose applied. Different parameters have proven useful for several other lasers, inducing changes within cell cultures and increasing the healing effect. Nevertheless, the optimal parameters have yet to be determined.[14]

Luger *et al*. used doses of about 64 J/cm^2 during 14 days. Although this dose could be excessive within the focused area, the authors believe that the scattering reduces the laser beams' energy level to between 3% and 6% of its original intensity.[15] In another study, the dose of 5 J/cm^2 at each of the different points around the tooth is lower than the one used by Luger *et al*. (64 J/cm^2). Still, the distribution of energy into ten points surrounding the canine teeth could be more adequate due to more homogeneous energy distribution.[15]

VIBRATION

Nishimura *et al*. have demonstrated the stimulatory effects of resonance vibration in accelerating tooth movement speed

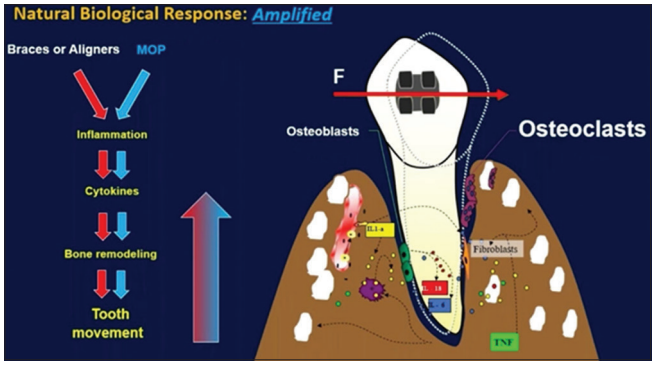

Figure 1: Mechanism of micro-osteoperforation

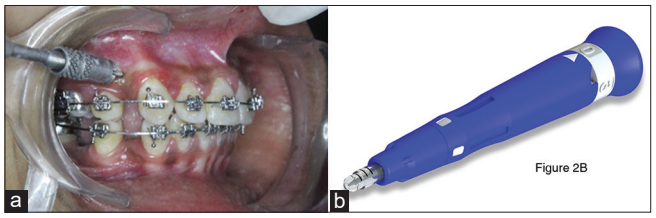

Figure 3: (a) Method of performing micro-osteo perforation (b) Propel Orthodontics

Table 1: Methods of accelerating tooth movement

Invasive methods	Noninvasive methods
Corticotomy	Laser
Piezocision	Photobiomodulation
Piezopuncture	Vibration
Micro-osteo perforations	Drugs
Distraction osteogenesis	Platelet-rich plasma

with no collateral damage to periodontal tissues. They have also shown the activation of the RANK RANKL signaling pathway in response to the loading of resonance vibration.[16] It was reported that signaling molecules, such as c-fos, MAPK, and nitric oxide, are increased in the PDL immediately after mechanical stimulation. Therefore, we considered it possible to activate PDL cells using an initial short-term stimulation.[17] Recently, a product named Acceledent has arrived on the market, which uses this technology [Figure 5]. It consists of an activator, which is the active part of the appliance that delivers the vibration impulses. The patient's usage of the appliance can be reviewed by connecting it to the computer. It is a portable device that has to be worn for 20 min a day. Using this device, various case studies have shown the treatment times to be reduced by up to 30%–40%.[18]

Patient benefits

- Reduced treatment time without compromised aesthetics
- Less prone to caries or gum disease with shortened treatment
- Clinical trial demonstrates an excellent root resorption safety profile.

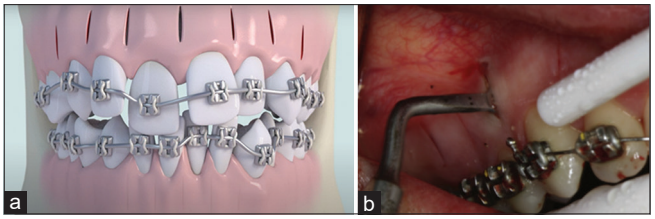

Figure 2: (a) Vertical gingival incisions made buccally (b) Method to perform piezocision with a piezotome

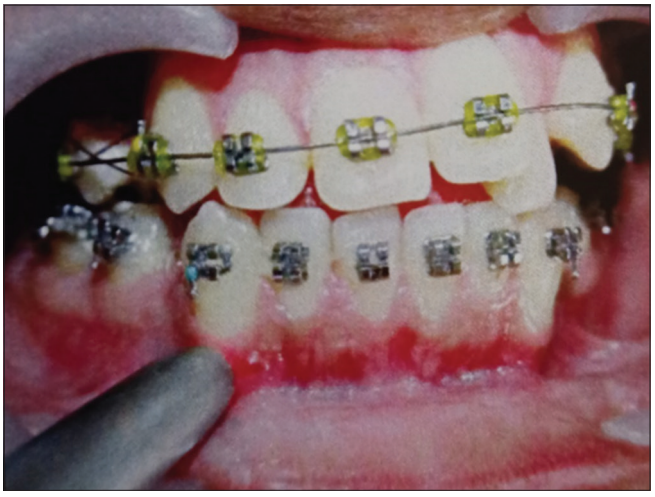

Figure 4: Method to use low-level laser therapy for accelerating tooth movement

DRUGS

Prostaglandins

PGs are a set of chemical messengers that belongs to a family of hormones called eicosanoids.[19] PGE2 is by far the most extensively tested agent for its capacity to modulate the tooth movement.[20] PGE2 increases the bone resorption by directly increasing the number of osteoclast cells and their bone resorptive activity during OTM.[2] Experiments on rats by Yamasaki showed that local administration of exogenous PGE2 increased the number of osteoclasts and accelerated OTM.[21] Yamasaki *et al*. also studied the effect of PGs on the rate of OTM in Macaca fuscata monkeys. They examined the possible side effects on gingival tissues. The results of experiments showed that the local administration of PGE1 or PGE2 in gingiva distal to canine to be retracted caused double the rate of tooth movement compared to the opposite, control side with no side effects on the gingiva except for a slight pain reaction consistent with tooth movement.[22] Human studies revealed that rate of OTM increased by two times by local injection of PGs. PGs cause a significant increase in the cyclic AMP and intracellular calcium. These intracellular second messengers are essential modulators of osteoclasts and bone resorption. It has also been demonstrated that repeated mucosal injections of 50 micrograms of PGE1

Figure 5: Commercially available Acceledent device

produced marked changes in alveolar bone morphology, such as increased resorption, extensive loss of bone matrix, fibrous replacement, and increased vascularity.[23]

Currently, the use of PGs is limited due to the need for repeated injection, severe pain associated with injection, and the possible risk of root resorption.[20] When PGE2 was administered in the presence of calcium gluconate, the calcium ions stabilized the root resorption while significantly increasing OTM.[24] Misoprostol, a synthetic PGE1 analog, demonstrated enhanced tooth movement without a significant increase in the amount of root resorption in doses as low as 10–25 mg/kg, twice daily.[25,26]

Vitamin D3

1,25 dihydroxycholecalciferol (1,25[OH] 2D3) or calcitriol is the most active hormonal form of vitamin D, regulating the calcium and phosphate serum levels by promoting their intestinal absorption and reabsorption in the kidneys. Furthermore, it helps in bone deposition and inhibits Parathyroid hormone (PTH) release.[27] Based on these mechanisms, one would expect that vitamin D3 should decrease tooth movement rate. On the contrary, local injection of vitamin D3 increased the rate of tooth movement by increasing the expression of RANKL by local cells, which activated the osteoclasts.[26]

Intraligamentous injection of 1,25D in dimethylsulfoxide in cats at weekly intervals demonstrated 60% further tooth movement than matched control teeth.[28] Microscopically, increased numbers of mononuclear osteoclasts recruitment and activation, resulting in more significant amounts of alveolar bone resorption on the pressure side, was observed, with no apparent clinical, microscopic, or biochemical side effects.[27] A comparative evaluation of PGs and vitamin D3 on OTM by Kale *et al*. showed that both significantly increase tooth movement amount compared to controls, with an increased number of osteoblasts on the external surface of the alveolar bone in the vitamin D3 group in comparison to prostaglandin. Thus, it was determined that 1,25 DHCC helped tooth movement through bone remodeling,[29] and it also improves the reestablishment of supporting tissue, which would improve posttreatment stability.[30]

PARATHYROID HORMONE

PTH causes an increased blood calcium level by stimulating calcium absorption from the intestine, reducing the calcium excretion by kidneys, and releasing calcium from bones. PTH has been shown to influence OTM by binding to PTH 1 receptors on osteoblasts, leading to the expression of insulin-like growth factor-1 (IFG-1), which promotes osteoblastogenesis and increases osteoblast survival, expression of RANKL, and osteoclast activation.[31] The role of PTH on the rate of tooth movement is dose-dependent. Continuous PTH elevation leads to bone resorption, while intermittent short elevations of the hormone level can be anabolic for the bone.[26] Li *et al*. investigated the effect of PTH injection on experimental tooth movement in rats. They found that intermittent exposure to PTH seems to increase bone formation, while continuous and long-term exposure (longer than 1–2 years) enhances bone resorption. Periodic exposure to PTH enhances osteoblast and subsequently, osteoclast activity, facilitating bone remodeling/turnover.[32] Soma's experiment on rats demonstrated that continuous subcutaneous infusion of PTH (10 μg PTH/100 g of body weight/day) accelerated the upper first molar's mesial movement. PTH infusion accelerated OTM by producing a 2–3-fold increase in the number of osteoclasts and enhancing bone resorption only in the compressed periodontium (pressure side) without undesired bone loss in other areas alveolar bone. It also caused rapid removal of necrotic tissue by stimulating bone cells to secrete proteolytic enzymes. Root resorption is usually initiated beneath the area of necrotic tissue in the compressed periodontal membrane. Thus, PTH may reduce the incidence of unfavorable root resorption by rapid removal of necrotic tissue from PDL during orthodontic therapy. Systemic administration of PTH may enhance undesired bone resorption in weight-bearing bones such as vertebrae. Therefore, it is more appropriate to give PTH locally into the tooth's circumferential tissue to be moved, rather than to provide it systemically in orthodontic therapy.[33]

RELAXIN

Relaxin is an ovarian hormone that belongs to the insulin superfamily. It helps in the widening of the pubic ligaments in females during delivery. Relaxin stimulates bone cell activity and connective tissue turnover. It is mainly known for the remodeling of soft tissue rather than bone.[26] Madan, Liu *et al*. evaluated the effect of relaxin on OTM and PDL in rats, which increased collagen at the tension site and decreased collagen.

It was concluded that the human relaxin might not accelerate OTM in rats; it only reduces PDL organization level, reduces the mechanical strength of PDL, and increases the tooth's mobility at the early stages of orthodontic treatment.[34,35] Results of a randomized clinical trial performed on humans using recombinant human relaxin showed no significant difference between the placebo control group and the relaxin group regarding the acceleration of tooth movement and relapse.[36]

CLINICAL APPLICATION FOR THE FUTURE

Exogenous biological molecules' administration to quicken tooth movement during orthodontic treatments has been mostly tested on animal experiments. However, clinical trials on humans are restricted since they are to be administered local injections, which can be discomforting and painful. However, certain molecules' administrations have shown promising results, for example, cytokine, PTH, and Vitamin D play an essential role in bone remodeling and tooth movement. In the physical approach, the LLLT is the most promising method; however, conflicting results are seen.

Furthermore, most of these experiments were done for a few weeks only, which is a brief time to notice any adverse effects. The surgical approach is the most tested with known predictions and long-lasting results. However, it is invasive and expensive, and patients do not opt for surgery unless it is the only option needed to have the right occlusion. Piezocision and micro-osteoperforation techniques are some of the newest methods in accelerating tooth movement, which has good clinical outcomes and is considered the least invasive in the surgical approach.

CONCLUSION

With the increasing number of adult patients seeking orthodontic treatment, the demand for newer, less invasive, and safer methods to accelerate OTM has also increased. Researchers have yet to seek a single most ideal technique for the patient. The invasive nature of the conventional surgical methods of accelerating the tooth movement has made them less desirable by the patients. Today, newer methods such as microsteoperforation, LLLT, vibrations show promising results in accelerating OTM with the least discomfort. The new devices like Propel and Acceledent used in conjunction with orthodontic treatment offer an efficient method to reduce treatment time. Yet, more research is necessary to substantiate claims and enhance technology and techniques in Orthodontics.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Fink DF, Smith RJ. The duration of orthodontic treatment. Am J Orthod Dentofacial Orthop 1992;102:45-51.
2. Nimeri G, Kau CH, Abou-Kheir NS, Corona R. Acceleration of tooth movement during orthodontic treatment – A frontier in orthodontics. Prog Orthod 2013;14:42.
3. Huang H, Williams RC, Kyrkanides S. Accelerated orthodontic tooth movement: Molecular mechanisms. Am J Orthod Dentofacial Orthop 2014;146:620-32.
4. Alikhani M, Raptis M, Zoldan B, Sangsuwon C, Lee YB, Alyami B, *et al.* Effect of micro-osteoperforations on the rate of tooth movement. Am J Orthod Dentofacial Orthop 2013;144:639-48.
5. Kole H. Surgical operations on the alveolar ridge to correct occlusal abnormalities. Oral Surg Oral Med Oral Pathol 1959;12:277-88.
6. Wilcko WM, Wilcko T, Bouquot JE, Ferguson DJ. Rapid orthodontics with alveolar reshaping: Two case reports of decrowding. Int J Periodontics Restorative Dent 2001;21:9-19.
7. Dibart S, Sebaoun JD, Surmenian J. Piezocision: A minimally invasive, periodontally accelerated orthodontic tooth movement procedure. Compend Contin Educ Dent 2009;30:342-4, 346, 348-50.
8. Kim YS, Kim SJ, Yoon HJ, Lee PJ, Moon W, Park YG. Effect of piezopuncture on tooth movement and bone remodeling in dogs. Am J Orthod Dentofacial Orthop 2013;144:23-31.
9. Liou EJ, Huang CS. Rapid canine retraction through distraction of the periodontal ligament. Am J Orthod Dentofacial Orthop 1998;114:372-82.
10. Işeri H, Kişnişci R, Bzizi N, Tüz H. Rapid canine retraction and orthodontic treatment with dentoalveolar distraction osteogenesis. Am J Orthod Dentofacial Orthop 2005;127:533-41.
11. Cruz DR, Kohara EK, Ribeiro MS, Wetter 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.
12. Saito S, Shimizu N. Stimulatory effects of low-power laser irradiation on bone regeneration in midpalatal suture during expansion in the rat. Am J Orthod Dentofacial Orthop 1997;111:525-32.
13. Kawasaki K, Shimizu N. Effects of low-energy laser irradiation on bone remodeling during experimental tooth movement in rats. Lasers Surg Med 2000;26:282-91.
14. Schindl A, Schindl M, Pernerstorfer-Schön H, Schindl L. Low-intensity laser therapy: A review. J Investig Med 2000;48:312-26.
15. Luger EJ, Rochkind S, Wollman Y, Kogan G, Dekel S. Effect of low-power laser irradiation on the mechanical properties of bone fracture healing in rats. Lasers Surg Med 1998;22:97-102.
16. Nishimura M, Chiba M, Ohashi T, Sato M, Shimizu Y, Igarashi K, *et al.* Periodontal tissue activation by vibration: Intermittent stimulation by resonance vibration accelerates experimental tooth movement in rats. Am J Orthod Dentofacial Orthop 2008;133:572-83.
17. Kikuiri T, Hasegawa T, Yoshimura Y, Shirakawa T, Oguchi H. Cyclic tension force activates nitric oxide production in cultured human periodontal ligament cells. J Periodontol 2000;71:533-9.
18. AcceleDent Faster Orthodontic Treatment to Straighten Teeth | Braces; 2020. Available from: http://acceledent.com/. [Last assessed on 2021 May 14].
19. Frost HM. The regional acceleratory phenomenon: A review. Henry Ford Hosp Med J 1983;31:3-9.
20. Kouskoura T, Katsaros C, von Gunten S. The potential use of pharmacological agents to modulate orthodontic tooth movement (OTM).

Front Physiol 2017;8:67.
21. Yamasaki K, Miura F, Suda T. Prostaglandin as a mediator of bone resorption induced by experimental tooth movement in rats. J Dent Res 1980;59:1635-42.
22. Yamasaki K, Shibata Y, Fukuhara T. The effect of prostaglandins on experimental tooth movement in monkeys (Macaca fuscata). J Dent Res 1982;61:1444-6.
23. 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.
24. Seifi M, Eslami B, Saffar AS. The effect of prostaglandin E2 and calcium gluconate on orthodontic tooth movement and root resorption in rats. Eur J Orthod 2003;25:199-204.
25. Kehoe MJ, Cohen SM, Zarrinnia K, Cowan A. The effect of acetaminophen, ibuprofen, and misoprostol on prostaglandin E2 synthesis and the degree and rate of orthodontic tooth movement. Angle Orthod 1996;66:339-49.
26. Alikhani M. Clinical Guide to Accelerated Orthodontics. With a Focus on Micro Osteoperforations. USA. Springer Int Publishing AG; 2017.
27. 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.
28. Collins MK, Sinclair PM. The local use of vitamin D to increase the rate of orthodontic tooth movement. Am J Orthod Dentofacial Orthop 1988;94:278-84.
29. Kale S, Kocadereli I, Atilla P, Aşan E. Comparison of the effects of 1,25 dihydroxycholecalciferol and prostaglandin E2 on orthodontic tooth movement. Am J Orthod Dentofacial Orthop 2004;125:607-14.
30. Kawakami M, Takano-Yamamoto T. Local injection of 1,25-dihydroxyvitamin D3 enhanced bone formation for tooth stabilization after experimental tooth movement in rats. J Bone Miner Metab 2004;22:541-6.
31. Dobnig H, Turner RT. Evidence that intermittent treatment with parathyroid hormone increases bone formation in adult rats by activation of bone lining cells. Endocrinology 1995;136:3632-8.
32. Li F, Li G, Hu H, Liu R, Chen J, Zou S. Effect of parathyroid hormone on experimental tooth movement in rats. Am J Orthod Dentofacial Orthop 2013;144:523-32.
33. Soma S, Iwamoto M, Higuchi Y, Kurisu K. Effects of continuous infusion of PTH on experimental tooth movement in rats. J Bone Miner Res. 1999;14:546-54.
34. Madan MS, Liu ZJ, Gu GM, King GJ. Effects of human relaxin on orthodontic tooth movement and periodontal ligaments in rats. Am J Orthod Dentofacial Orthop 2007;131: 10.e1-10.
35. Liu ZJ, King GJ, Gu GM, Shin JY, Stewart DR. Does human relaxin accelerate orthodontic tooth movement in rats? Ann N Y Acad Sci 2005;1041:388-94.
36. McGorray SP, Dolce C, Kramer S, Stewart D, Wheeler TT. 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 2012;141:196-203.