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Various Acceleratory Orthodontic Techniques and their Associated Risks and Benefits- A Review

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Abstract

The primary concern among patients and orthodontists is the prolonged treatment time. In the present scenario where patients desire quicker results, the extended treatment duration is a deterrent for seeking orthodontic treatment. Psychological burnout, poor oral hygiene due to difficulty in performing oral prophylaxis, food lodgment leading to gingival and periodontal diseases, and dental caries are among the many associated problems with orthodontic treatment. Multiple methods have been introduced to improve the rate of tooth movement. This article explains the various mechanisms of action of different acceleratory orthodontic techniques and their associated pros and cons.

Keywords: Prolonged Treatment Duration; Psychological Burnout; Acceleratory Orthodontic Techniques

Abbreviations

TNF: Tumor Necrosis Factor; OPG: Osteoprotegerin; PDL: Periodontal Ligament; PTH: Parathyroid Hormone; PRP: Platelet Rich Plasma; LLLT: Low-Level Laser Therapy; PEMF: Pulsed Electromagnetic Field; RAP: Regional Acceleratory Phenomenon; MOP: Micro-Osteoperforation.

Introduction

Orthodontics has made great strides in achieving desired results in esthetics and functionality both clinically and technically, due to development of newer appliance design and treatment modalities. However, the biomechanical systems have reached their limit in terms of improving the rate of tooth movement [1]. The patients undergoing the treatment often loose motivation to continue it and face consequences of the inability to maintain proper oral hygiene due to the prolonged duration of treatment.

Various methods have been employed to improve the rate of orthodontic tooth movement. However, there are many uncertainties regarding their efficiency, patient tolerance, comfort, and the possible associated effects on the surrounding oral structures. The various techniques for increasing the rate of tooth movement are as follows.

Biological Approach

In this approach various molecules are used exogenously to improve the rate of tooth movement

Use of Cytokines: Cytokines such as interleukins (ILs) and tumor necrosis factor (TNF) govern the osteoclastic activity and osteoprotegerin (OPG) causes osteoblastic activity. The bone remodeling is dictated by the balance between RANK- RANKL system and OPG [1]. Experiments have been conducted on rats using the above mentioned cytokines and it has been demonstrated that transfer of RANKL gene and OPG gene to the periodontal ligament (PDL) has exhibited increase and decrease in tooth movement respectively [2]. Studies have also shown that the tooth movement in adults is slower than in juveniles as the RANKL/OPG ratio is lower in the former [1]. Human studies conducted have shown accelerated tooth movement using RANKL, however, this study also exhibited root resorption [3].

Use of Prostaglandins (PGs): PGs are inflammatory mediators which promote osteoclastic activity by increasing the number of osteoclasts. Yamasaki pioneered in investigating the effects of PGs in acceleration of tooth movement by local administration in monkeys and rats [4,5]. Injection of exogenous PGs in rats over an extended period also showed improvement in the rate of tooth movement [6]. Root resorption was seen with the increase in concentration of PGs. Studies have shown that calcium can be used to stabilize root resorption while accelerating the tooth movement [7].

Use of Vitamin D3: The hormonal form of vitamin D (1, 25 dihydroxycholecalciferol) plays a vital role in calcium homeostasis with calcitonin and parathyroid hormone (PTH). Accelerated tooth movement was demonstrated in cats when vitamin D metabolite was injected into the PDL for several weeks [8]. It was also observed that the number of osteoblasts also increased in the pressure side indicating that vitamin D is more effective in bone turnover [9]. A review article from the previous decade shows that Vit D3 is an effective method of accelerating the rate of tooth movement [10]. Usage of Vit D3 has also shown reduced amounts of root resorption by maintaining the balance between osteoblastic and osteoclastic activity [11,12].

Use of Parathyroid Hormone (PTH): PTH can be used as an agent of increasing the rate of tooth movement by increasing the osteoclastic activity. Studies have shown that local application of PTH is far more effective than systemic distribution [13]. PTH can be used in gel form for slow and sustained release or can be locally injected [14]. However, the potential risk of root and alveolar bone resorption warrants further research.

Use of Relaxin: Relaxin is a hormone that is produced during childbirth. It is responsible for the relaxation of the pubic symphysis during parturition. This naturally occurring hormone might be used as an adjunct to orthodontic therapy as it appears to have the capacity to alter the physical properties of the connective tissue within sutures, gingival tissue, and the PDL [15]. The collagen is increased on the tension side and reduced on the compression side under the influence of this hormone [1]. The reorganization of the PDL can increase tooth mobility and reduce mechanical strength [16].

Use of Platelet Rich Plasma (PRP): Platelet-rich plasma (PRP) is an autologous concentrate of platelets in a small volume of plasma. It has been used extensively as a source of autologous growth factors and secretory cytokines provided by the concentrated platelet suspension [17]. It was introduced in dentistry by Robert Marx in 1998 for the mandibular reconstructive procedure to increase the radiographic maturation rate of the bone graft [18]. PRP contains multiple growth factors such as platelet derived growth factor, epidermal growth factor, transforming growth factor etc. PRP is known to cause vasodilation which increases the osteoclastic and cementoblastic activities. It also aids in the formation of new blood vessels and nerve fibers which causes active osteogenesis by production and activation of neurotransmitters and cytokines. This causes increasein the rate of tooth movement with minimum effect on the root length [11,18,19].

Device Assisted Treatment

This technique advocates the use direct current, magnetic field, vibration, laser etc.

Use of Cyclic Force Device: Low level mechanical oscillatory signals (vibrations) have been used to prevent osteoporosis in post-menopausal women. These mechanical vibrations are known to improve bone metabolism, suggesting that dynamic loading improves bone formation and increases orthodontic tooth movement compared to a static force [20]. The commonly used devices are accledent at 0.25N cyclic force and 30Hz. The anabolic activity of this regime is also exhibited by the lack of change in root length as demonstrated in multiple studies [21,22].

Use of Direct Electric Current: In this technique direct current is applied to anode and cathode at the pressure and tension side respectively to generate local acceleration in bone remodelling. Electric stimulation enhances cellular enzymatic phosphorylation activities in periodontal tissues which in turn aides in accelerating alveolar bone turnover [23]. In a study conducted by Shaadouh RI, et al. [24]. A electric current at 1.5V was applied to each anterior tooth. The results showed significant increase in tooth movement with minimum patient discomfort and pain [24]. However, the duration of application of device was not mentioned. Further studies are required regarding this technique.

Use of Low-Level Laser Therapy: Low-level laser therapy (LLLT) or photobiomodulation stimulates the proliferation of osteoblasts, osteoclasts, and fibroblasts, which in turn accelerates bone remodeling leading to rapid tooth movement [1]. LLLT enhances the production of ATP and cytochrome C [25]. Low-level laser therapy is also known to reduce patient discomfort. The effects of LLLT are localized and anabolic in nature [26]. Minimal change is observed in root lengths of the tooth exposed to LLLT. This is attributed to the angiogenesis and proliferation of cementoblasts and fibroblasts and reduced RANKL/OPG ratio [27]. The commonly used wavelength for LLLT is 800-1500 nm for 15-30 sec.

Use of Pulsed Electromagnetic Field (PEMF): PEMF is utilized to promote cellular activity and tissue healing. PEMF interacts with the charged particles within cells inducing intracellular signaling pathways. It promotes osteoblastic activity by stimulating the proliferation and differentiation of osteoblasts and by enhancing blood flow to the treated area. It also reduces osteoclastic activity thereby aiding in reducing associated root resorption. With the stimulation of endorphin release it also aids in reducing pain [28].

Surgical Approach

These techniques are commonly used in adult patients by intentional introduction of inflammation to enhance the rate of tooth movement.

Interseptal Alveolar Surgery: Commonly used for canine retraction where the bone distal to the canine is surgically undermined and is bent and fractured by the heavy force generated by the distraction device. The procedure is combined with the premolar extraction. The extraction socket is deepened to the length of the canine apex, and the interseptal bone distal to the canine is reduced to 1 to 1.5 mm in thickness using round and cylindrical carbide burs. If present, the interradicular septal bone of the socket is also removed. This technique employs reduced resistance from alveolar bone, bone bending and regional acceleratory phenomenon (RAP). This technique also requires additional consideration of adjacent anatomical landmarks [29]. Animal studies show that the amount of root resorption may be higher in this technique, but are not clinically significant [30]. Further studies are needed to ascertain other periodontal ill effects, pulp vitality, and general patient comfort.

Corticotomy and Osteotomy: In the osteotomy, segments of bone are cut to the medullary bone and are separated to be moved as a unit. The procedure of corticotomy involves cutting and perforating the cortical bone without involving the medullary bone, with the intention of reducing resistance for tooth movement from the cortical bone. The procedure was introduced by Kole and was further modified by Wilco. The technique also employs RAP to accelerate the tooth movement. However, the extensive invasiveness of this procedure does not make it a popular choice. In adults there may be need for additional bone grafting to provide alveolar housing while moving the tooth. Periodontal defects, alveolar bone resorption, gingival defects and root resorption ismuch higher compared to conventional orthodontics [31].

Piezocision: In 2007, Vercellotti and Podesta performed corticotomies using conventional flap elevations and piezosurgery for rapid tooth movement. After that, Dibart et al. reported a method of performing only piezosurgery without flap elevation and named it “Piezocision” [30]. This method requires a piezo-electric device and causes minimal tissue damage. Sutures are not needed unless bone graft is used. It also has an added advantage of being used along with clear aligner [1]. It is a minimally invasive procedure with minimal periodontal trauma and root resorption.

Micro-Osteoperforation (MOP): MOP is a minimally invasive procedure and less painful thereby improving patient compliance among the other surgical interventions. It can be performed by the orthodontist themselves using a mini-implant and a driver. The rate of tooth movement is similar to that of piezocision. Multiple studies have indicated increased root resorption in comparison to other acceleratory orthodontic treatments, however they are not clinically significant [32].

Conclusion

With the numerous options available to enhance the rate of orthodontic tooth movement, one must analyze the associated risk- benefit ratio. The patient must be informed about the procedure and the possible risks associated with it and an informed consent must be obtained. The biological differences among the patients, their ability to maintain oral hygiene, frequency of appointment, socio- economic background and the clinician’s ability must be considered to choose the best option for acceleratory orthodontic treatment.

References

1. Nimeri G, Kau CH, Kheir NS, Corona R (2013) Acceleration of Tooth Movement during Orthodontic Treatment-A Frontier in Orthodontics. Prog Orthod 14: 42.

2. Kanzaki H, Chiba M, Takahashi I, Haruyama N, Nishimura M, et al. (2004) Local OPG Gene Transfer to Periodontal Tissue Inhibits Orthodontic Tooth Movement. J Dent Res 83(12): 920-925.

3. Nishijima Y, Yamaguchi M, Kojima T, Aihara N, Nakajima R, et al. (2006) Levels of RANKL and OPG in Gingival Crevicular Fluid during Orthodontic Tooth Movement and Effect of Compression Force on Releases from Periodontal Ligament Cells in Vitro. Orthodontics & Craniofacial Research 9(2): 63-70.

4. Yamasaki K, Shibata Y, Fukuhara T (1982) The Effect of Prostaglandins on Experimental Tooth Movement in

Monkeys (*Macaca Fuscata*). J Dent Res 61(12): 1444-1446.

5. Yamasaki K, Miura F, Suda T (1980) Prostaglandin as a Mediator of Bone Resorption Induced by Experimental Tooth Movement on Rats. J Dent Res 59(10): 1635-1642.
6. Leiker BJ, Nanda RS, Currier GF, Howes RI, Sinha PK (1995) The Effects of Exogenous Prostaglandins on Orthodontic Tooth Movement in Rats. Am J Orthod Dentofacial Orthop 108(4): 380-388.
7. Seifi M, Eslami B, Saffar AS (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.
8. Collins MK, Sinclair PM (1988) The Local Use of Vitamin D to Increase the Rate of Orthodontic Tooth Movement. Am J Orthod Dentofacial Orthop 94(4): 278-284.
9. Kale S, Kocadereli I, Atilla P, 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.
10. Wirapradina R, Indriani RI, Pandelaki RV, Pakpahan EL (2024) The Effect of Vitamin D3 on Tooth Movement in Orthodontic Treatment Moestopo. International Review on Social, Humanities and Sciences 4(1): 10-16.
11. Navya S, Prashantha GS, Sabrish S, Roshan MS, Mathew S (2022) Evaluation of the Effect of Local Administration of PRP vs Vitamin D3 on the Rate of Orthodontic Tooth Movement and the Associated External Apical Root Resorption. J Oral Biol Craniofac Res 12(6): 879-884.
12. Hasani NR, Ibrahim AI (2021) Effect of Accelerated Canine Retraction by Vitamin D3 Local Administration on Apical Root Resorption, Alveolar Bone Integrity, and Chair-side Time: A Prospective Clinical Study. International Medical Journal 28(6): 654-657.
13. Soma S, Matsumoto S, Higuchi Y, Yamamoto T, Yamashita K, et al. (2000) Local and Chronic Alication of PTH Accelerates Tooth Movement in Rats. J Dent Res 79(9): 1717-1724.
14. Yamamoto T, Rodan GA (1990) A Model for Investigating the Local Action of Bone-acting Agents in Vivo: Effects of hPTH (1-34) on the Secondary Spongiosa in the Rat. Calcif Tissue Int 47: 158-163.
15. Nicozisis JL, Cederquist HD, Tuncay OC (2000) Relaxin Affects the Dentofacial Sutural Tissues. Clin Orthod Res 3(4): 192-201.
16. Madan MS, Liu ZJ, Gu GM, King GJ (2007) Effects of Human Relaxin on Orthodontic Tooth Movement and Periodontal Ligaments in Rats. Am J Orthod Dentofacial Orthop 131(1): e1-e10.
17. Nakornnoi T, Leethanakul C, Samruajbenjakun B (2019) The Influence of Leukocyte-platelet-rich Plasma on Accelerated Orthodontic Tooth Movement in Rabbits. Korean J Orthod 49(6): 372-380.
18. Jain S, Bunkar AK (2020) Overview of Platelet-rich Plasma: Orthodontics Perspective. Int J Contemp Dent Med Rev 2020: 005072.
19. Seddik HA, Ibrahim SA, Attia MS (2020) Evaluation of Root Length Accompanying Platelet Rich Plasma Injection as a Technique for Orthodontic Tooth Movement Acceleration (A Comparative Study). Al-Azhar Dental Journal of Dentistry 7(4): 17.
20. Pavlin D, Anthony R, Raj V, Gakunga PT (2015) Cyclic Loading (Vibration) Accelerates Tooth Movement in Orthodontic Patients: A Double-blind, Randomized Controlled Trial. Seminars in Orthodontics 21(3): 187-194.
21. Kau CH (2011) A Radiographic Analysis of Tooth Morphology following the Use of a Novel Cyclical Force Device in Orthodontics. Head Face Med 7: 14.
22. Wang J, Lamani E, Christou T, Li P, Kau CH (2020) A Randomized Trial on the Effects of Root Resorption after Orthodontic Treatment using Pulsating Force. BMC Oral Health 20(1): 238.
23. Davidovitch Z, Finkelson MD, Steigman S, Shanfeld JL, Montgomery PC, et al. (1980) Electric Currents, Bone Remodeling, and Orthodontic Tooth Movement. I. The Effect of Electric Currents on Periodontal Cyclic Nucleotides. Am J Orthod 77(1): 14-32.
24. Shaadouh RI, Hajeer MY, Sabbagh R, Alam MK, Mahmoud G, et al. (2023) A Novel Method to Accelerate Orthodontic Tooth Movement using Low-Intensity Direct Electrical Current in Patients Requiring En-Masse Retraction of the Uer Anterior Teeth: A Preliminary Clinical Report. Cureus 15(5): e39438.
25. Karu TI (2008) Mitochondrial Signaling in Mammalian Cells Activated by Red and Near-IR Radiation. Photochem Photobiol 84(5): 1091-1099.
26. Joseph A, Prashantha GS, Sabrish S, Sagarkar R, Mathew S (2022) Comparison of Rate of Tooth Movement, Root Resorption and Pulp Vitality during En Masse Anterior Retraction with Micro-Osteoperforation and Low Level

Laser Therapy: A Randomised Clinical Trial. Journal of Clinical & Diagnostic Research 16(8): ZC31-ZC36.

27. Ng D, Chan AK, Papadopoulou AK, Dalci O, Petocz P, et al. (2018) The Effect of Low-Level Laser Therapy on Orthodontically Induced Root Resorption: A Pilot Double Blind Randomized Controlled Trial. Eur J Orthod 40(3): 317-325.

28. Gandedkar NH, Dalci O, Darendeliler MA (2024) Accelerated Orthodontics (AO): The Past, Present and the Future. Seminars in Orthodontics 30(2024) 172-182.

29. Leethanakul C, Kanokkulchai S, Pongpanich S, Leepong N, Charoemratrote C (2014) Interseptal Bone Reduction on the Rate of Maxillary Canine Retraction. Angle Orthod 84(5): 839-845.

30. Cohen G, Campbell PM, Rossouw PE, Buschang PH (2010) Effects of Increased Surgical Trauma on Rates of Tooth Movement and Apical Root Resorption in Foxhound Dogs. Orthod Craniofac Res 13(3): 179-190.

31. Lee W (2018) Corticotomy for Orthodontic Tooth Movement. J Korean Assoc Oral Maxillofac Surg 44(6): 251-258.

32. Shahabee M, Shafaee H, Abtahi M, Rangrazi A, Bardideh E (2020) Effect of Micro-Osteoperforation on the Rate of Orthodontic Tooth Movement-A Systematic Review and A Meta-analysis. Eur J Orthod 42(2): 211-221.