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Research Article

VIBRATION IN ORTHODONTICS: OVERVIEW

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ABSTRACT

Orthodontic treatment being based wholly on the response of the bone and the tissue surrounding the bone takes an ample of time to achieve desired amount of tooth movement. This long treatment time burden the patient and the doctor with lack of patient cooperation, periodontal problems, improper oral hygiene, external root resorption, dental caries, and gingival recession, etc. Attempts to lessen the treatment duration by accelerating tooth movements created a major focus and became popularized as accelerated orthodontics that involves both invasive and noninvasive methods. The attempts become innovated focusing accelerated orthodontics with minimum drawbacks. The purpose of this article is to analyze and comprehend data of the studies developed on the mechanical vibration as a tool for accelerated orthodontic treatment.

INTRODUCTION

The main concern of the patients and parents for seeking orthodontic treatment is its long duration. Orthodontic tooth movement (OTM) depends on the response of tissues around the root which involves remodeling of the alveolar bone which stands for the long duration of orthodontic treatment.[1,2,3,4] For shortening the duration of orthodontic treatment various surgical and non-surgical methods have been tried to accelerate orthodontic tooth movement. Surgical methods such as interseptal alveolar surgery, corticotomy, corticision, piezocision and microosteoperforations increase the speed of tooth movement. However surgical methods are expensive, needs patients' compliance and have post-surgical complications.[5,6,7]

Beside surgical method, mechanical stimulation can also increase the speed of orthodontic tooth movement. These modalities include low level laser therapy, direct electric current and cyclic vibrations. The purpose of this article is to review the role of cyclic vibration as a method to increase the velocity of tooth movement.

Evolution of Vibration in Orthodontics[6,7,8]

As early as 1979, Shapiro and colleagues reported the use of pulsating force-induced piezoelectricity to stimulate tooth movement.

In 1982, Kurz received a patent for a vibrating headgear/ mouthpiece device.

In 1986, Kiev concluded that vibration at 50Hz for 60-360 seconds every two or three days reduced the time needed to move a tooth by a factor of 1.5-2 times.

Although academic interest in the orthodontic effects of vibration waned until the beginning of the 21st century, it persisted in orthopedic medicine.

In 2003, animal studies demonstrated an increased sutural response and more rapid tooth movement after vibratory stimulation.

In 2009 using a low-frequency pulse vibration prototype, Kau, reported accelerated tooth movement in both arches of 14 patients.

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Mode of Vibrations

Vibrations to accelerate tooth movement were tried in two forms

- Resonance vibration.
- Cyclic force therapy or micro pulse therapy.

***Accele Dent*:** The device introduced clinically for accelerated orthodontic tooth movement

Principle and mechanism of action

The complex of the tooth and periodontal ligament (PDL) is considered viscoelastic and so dynamic loading improves bone formation and increases orthodontic tooth movement compared to a static force.

The conventional orthodontic treatment modality provides a constant pressure applied to the tooth which causes the periodontal fibers to become cell-free which results in stand-still of the tooth. Compression of PDL results in reduced blood supply and tissue necrosis, and the tooth will not move again until the bone subjacent to the hyalinized tissue has been eliminated by undermining resorption. The magnitude of the force generally will determine the duration of the hyalinization and strong forces produce a wide hyalinization area of long duration thus delaying the tooth movement.[8,9]

When a tooth is subjected to a continuous force exerted on it, the periodontal membrane is compressed on the pressure side creating an area that is cell-free with occluded blood vessels, and reduced oesteoclastic activity. On the contrary if light orthodontic force is applied the flow of blood to the area will not be restricted, and consequently oesteoclastic activity will be more vigorous and bone resorption will be increased and hence the shift of tooth to the resorbed area.[10]

Vibrations as pressure impulses when introduced to the tooth being moved, rather than a continuous force with every pressure impulse from the appliance, the tissue pressure in the periodontal membrane and adjacent bone tissue will be increased. When the pressure is relaxed, the tissue pressure in the PDL and adjacent bone tissue will be reduced. This fluctuation from high pressure to low pressure in the periodontal and adjacent tissue will result in a pump-like action that will suck blood and tissue fluid into the area, and will then expel fluid from the area, for each cycle of operation. This serves to increase the cellular action around the moving tooth, giving rise to more oesteoclasts for bone resorption and more oesteoblasts for bone apposition.

Molecular basis behind the acceleration of tooth movement is the physical forces acts as external force for all the cells including the bone forming cells. BMP-2- induced bone formation and cellular mineralization were enhanced after various types of biophysical stimulation of bone cells.

Vibration stimulates inflammation that alters the periodontal apparatus and creates osteogenic effects through genetic expression, cytokine activity, cellular changes, or recruitment, thereby enhancing tooth movement.Apart from biological effects, vibration may also work on a biomechanical level to accentuate orthodontic tooth movement. In accord to Braun and colleagues the dynamic environment of the oral cavity ("vibrational" perturbations) has the primary influence in moderating the rate of tooth movement with fixed appliances.

The amplitude of arch wire vibration is the most important factor.

The rate of orthodontic tooth movement in two ways: reducing the lag" phase by stimulating changes in the periodontal apparatus, or inducing mechanical perturbations within the appliance interface.

The application of resonance vibration might accelerate orthodontic tooth movement via enhanced RANKL expression in the PDL with no additional damage to periodontal tissues, such as root resorption.

Effect of Vibration on Tooth Movement

According to pavlav *et al* the application of cyclic loading (vibration) of 0.25N (25g) at the frequency of 30Hz as an adjunct to treatment with a fixed orthodontic appliance, significantly increases the rate of orthodontic tooth movement. Studies started developing obased on the effect of vibration on different types of tooth movement.[10,11]

Adding to the studies on effect of mechanical vibration on tooth movement a study cconducted by Prof. Nada and Prof Khudair in 2014 showed mechanical vibration can accelerate orthodontic tooth movement with its experiment using 14 male arabino rabbit. It was observed that the increased rate of tooth movement is due to the reduced initial lag phase when the force was applied.[12]

Effect of Vibration on Alignment and Levellng

The study on effect of vibration on the rate of leveling and alignment by Bowman concluded the time required for alignment and levelling was reduced with the use of vibration as an adjunct.[10]

Effect of Vibration on Molar Distalisation

Vibration as an adjunct to tooth movement has been found to accelerate the molar movement which serves as a common strategy in class II correction. According to the study of jay bowman a 30% increase in the rate of leveling of the lower arch, nearly three times the typically reported 1mm per month of tooth movement in the maxilla, a 150-200% reduction in the time required to move a tooth, and an upper-canine retraction rate of 1.16mm per month vs. .79mm per month for a control group10 (rates quite similar to the present results). [11]

Vibrations and Orthodontically Induced Root Resorption

Orthodontically induced root resorption (RR) is an adverse sequela of orthodontic treatment. Physiological root resorption occurs naturally and is responsible for the root resorption of deciduous teeth, whereas pathological RR is usually inflammatory in nature. Longer duration of orthodontic treatment is associated with increased chances of inflammation and inflammation associated root resorption.

According to the study by Yadav *et al* in vivo experiments showed a trend toward increase in root volume with different frequencies of mechanical vibration and in vitro gene expression analyses showed that with 20 Hz of mechanical vibration, there was a significant decrease in RANKL and a significant increase in OPG expression.

Osteoprotegerin (OPG) and receptor activator of nuclear factor-kappa B ligand (RANKL) are paracrine regulators of osteoclastogenesis and cementoclastogenesis. Among the many signals released in response to mechanical vibration, RANKL and OPG are regarded as two critical molecules regulating osteoclasts. RANKL is expressed as a transmembrane protein in osteoblasts, whereas OPG is a protein secreted by the osteoblasts acting as a decoy receptor blocking the RANKL-RANK ligand interaction, thus antagonizing the formation of mature osteoclasts.

Mechanical vibration has been shown to stimulate proliferation and differentiation of mesenchymal stem cells into osteogenic and chondrogenic lineage. These findings suggest that mechanical vibration has broad tissue-regeneration potential and in the near future might be used for hard tissue (bone and root) repair and regeneration (apical RR)[9]

Low-magnitude, high-frequency vibrations decrease osteoclastic activity. Results show that LFMV alters the levels of RANKL and OPG expression, thus altering osteoclastic activity and that the expression of RANKL significantly decreases with 20-Hz vibration compared with other experimental groups. Mechanical vibration with frequencies of 5, 10, and 20 Hz for 15 minutes on days 1, 4, 7, 10, and 13 did not significantly affect root volume. However, there was a trend toward increasing root volume with different low-frequency mechanical vibrations.[10]

Low Frequency Mechanical Vibration on Retention in Orthodontic Relapse Model

Retention the last but important phase of an orthodontic treatment serves to be a very crucial phase to be handled. As the teeth have a natural tendency to move back to its original position relapse occurs more easily and brings all the long term efforts in vain. The reason for relapse is multifactorial and is directly related to muscular imbalance leading to bone turnover.

In a recent study, Kalajzic *et al*. Showed the inhibitory effect of the cyclical forces (30 Hz and 40g of force applied through electromechanical actuator) on the orthodontic tooth movement due to decreased catabolic bone modelling (decreased number and surface of osteoclast with cyclical vibration).

There was no statistically significant difference in the amount of relapse between the relapse-only and relapse + 30 Hz vibration groups. However, there was a trend of decrease in relapse with 30 Hz mechanical vibration. There was no significant difference in BVF among the different experimental groups. However, the tissue density was significantly increased with 30 Hz vibration. The LFMV at 30 Hz did not have a deleterious effect on the integrity of PDL. In fact, LFMV helped in maintaining the thickness and integrity of the PDL after the application of orthodontic force.

Future of Vibrational Therapy

The apparent limitations of current commerciallyavailable vibration devices should not diminish the potential importance of vibration therapy. Setting aside applications such as implant dentistry and prosthodontics suggested by the osteogenic properties associated with vibration therapy, there are atleast four important clinically beneficial orthodontic applications that can be anticipated. These potential applications are: 1) as a nightly clear aligner seating device; 2) analgesia; relief from normal discomfort associated with orthodontic treatment; 3) accelerated orthodontic tooth movement; 4) and enhancement of retention to minimise orthodontic relapse.

Advantages

Decreases the time duration of the orthodontic treatment time
Decreases the chances of root resorption
Decreases the chance of mini implant failure
Increases the fitness of clear aligner thereby regularizing the time period of tray progression
It has a big advantage of reducing the patient discomfort by its non-pharmological analgesic effect.

Disadvantges

Patient cooperation for the timely use of the vibration device.
Specialized device needed, which add additional cost.

CONCLUSION

The application of vibration increases the rate of tooth movement through enhanced expression of RANKL expression in the periodontal ligament fibre. However vibration in the field of orthodontics is in its early phase, more studies and investigation are required for clinical safety and efficacy of vibration in field of orthodontics. As most studies highlights it's anabolic effect on bone further studies may be required to create an in depth knowledge about standardization of its

protocol to bring out the desired anabolic or catabolic effect is mandatory.

References

1. C. Rubin, A.S. Turner, R. Müller, E. Mittra, K. McLeod, W. Lin, *et al*. Quantity and quality of trabecular bone in the femur are enhanced by a strongly anabolic, noninvasive mechanical intervention. *J Bone Miner Res.* 2002; 17(2):349-357.
2. R. Garman, G. Gaudette, L. Donahue, C. Rubin, S. Judex. Low-level accelerations applied in the absence of weight bearing can enhance trabecular bone formation. *J Orthop Res*. 2007; 25(6):732-740.
3. C. Rubin, R. Recker, D. Cullen, J. Ryaby, J. McCabe, K. Mc- Leod. Prevention of postmenopausal bone loss by a low-magnitude, high-frequency mechanical stimuli: a clinical trial assessing compliance, efficacy, and safety. *J Bone Miner Res*. 2004; 19(3):343-351.
4. M.P. Verschueren, M. Roelants, C. Delecluse, S. Swinnen, D. Vanderschueren, S. Boonen. Effect of 6-month whole body vibration training on hip density, muscle strength, and postural control in postmenopausal women: a randomized controlled pilot study. *J Bone Miner Res*. 2004; 19(3):352-359.
5. T.J. Fischer. Orthodontic treatment acceleration with corticotomy-assistedexposure of palatally impacted canines. Angle Orthod.2007; 77:417-420.
6. M. Cassetta, S. Di Carlo, M. Giansanti, V. Pompa, G. Pompa,E. Barbato. The impact of osteotomy technique for corticotomyassisted orthodontic treatment (CAOT) on oral health-related quality of life. Eur Rev Med Pharmacol Sci. 2012;16:1735-1740
7. Alikhani M, Raptis M, Zoldan B, Sangsuwon C, Lee YB, Alyami B, Corpodian C, Barrera LM, Alansari S, Khoo E, Teixeira C. Effectof micro-osteoperforations on the rate of tooth movement. *Am J Orthod Dentofacial Orthop*. 2013; 144(5):639-648.
8. Kau, Chung H., Jennifer T. Nguyen, and Jeryl D. English. "The clinical evaluation of a novel cyclical force generating device inorthodontics." Orthodontic Practice. 2010; 1:1.
9. Leethanakul C, Suamphan S, Jitpukdeebodintra S, Thongudompom U, Charoemratrote C. Vibratory stimulation increases interleukin-1 beta secretion during orthodontic tooth movement. Angle Orthod. 2015; 85; (5):74-80.
10. Bowman, S. Jay. "The Effect of Vibration on the Rate of Leveling and Alignment." *Journal of Clinical Orthodontics*. 2014; 48(11):678-688.
11. S. Jay bowman. The Effect of Vibration on Molar Distalization. JCO 2016.
12. N R Woodhouse *et al*. Supplemental Vibrational Force During Orthodontic Treatment: A Randomized Study, *Journal of Dental Research*. May 2015; 94(5):682-689.Sumit Yadava *et al*. The effect of mechanical vibration on orthodontically induced root resorption.
13. Segal GR, Schiffman PH, Tuncay OC. Meta analysis of the treatment-related factors of external apical root resorption. *Orthod Craniofac Res* 2004; 7:71-8.
14. Sumit Yadav *et al*. The effect of low-frequency mechanical vibrationon retention in an orthodontic relapse model. *European Journal of Orthodontics*, 2015, 1-7.
15. Makoto Nishimura *et al*. Intermittent stimulation by resonance vibration accelerates experimental tooth movement in rats. *Am J Orthod Dentofacial Orthop* 2008; 133:572-83.
16. AmitLala. Vibration therapy in orthodontics: Realising the benefits. vibration therapy trends and applications 2016
17. DubravkoPavlin*et al*., Cyclic Loading (Vibration) Accelerates Tooth Movement in Orthodontic Patients: A Double-Blind, Randomized Controlled Trial. Semin Orthod. http://dx.doi.org/10.1053/j.sodo.2015.06.005.
18. Sumit Yadav, Thomas Dobieb, Amir Assefniac, HimankGuptac, ZanaKalajzicd, RavindraNandae. Effect of low-frequency mechanical vibration on orthodontic tooth movement. AJODO. September 2015; 148:440-449.
19. Lala A. Vibration therapy in orthodontics: Realizing the benefits. Ortho. 2016; 1(1):24-27.
20. Kalajzic Z, Polusa EB, Utreja A, *et al*. Effect of cyclical forces on the periodontal ligament and alveolar bone remodeling during orthodontic tooth movement. Angle Orthod. 2014; 84(2):297-303.
21. Zhang C, Zhang L, Xu X, Duan P, Wu H. Mechanical vibration may be a novel adjuvant approach to promoting stability and retention following orthodontic treatment. Dent. Hypotheses.2014; 5(3):98-102.
22. Birgit Thilander. Biological basis of orthodontic relapse. Seminarsin orthodontics. 2000; 6:195-205.

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