

Acceleratory Orthodontics - The Race Against Time

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Abstract

The demand for orthodontic care has been increased amongst the adult patients now a days, and subsequently the demand for the lesser treatment time also. This led to a rise in the development of ways to accelerate the orthodontic tooth movement and scale back the general treatment time. Numerous procedures are introduced to reinforce the speed of tooth movement that embrace the use of low level laser therapy, pulsed electromagnetic fields, electrical currents, Surgical means like corticotomy, dentoalveolar distraction, periodontal distraction, piezocision etc. The aim of this article is to discuss the various treatment modalities which is currently available to reduce the orthodontic treatment time and obtaining a faster results.

Keywords: *Acceleratory Orthodontics, Corticotomy, Piezocision, Micro-Osteoperforation, Low-Level Laser Therapy*

1. INTRODUCTION

Orthodontic Tooth Movement (OTM) is a biological process characterized by periodontal ligament(PDL) and alveolar bone remodeling in response to the orthodontic force which will promote extensive cellular and molecular changes in the periodontium.

Orthodontic treatment time ranges between 18.1 -24.5 months and 19.4 to 27.9 months for non-extraction and extraction therapies, respectively¹. Today, it is still very demanding to reduce the duration of orthodontic treatments.

Several orthodontic companies now offer brackets, techniques and other appliances that claim to reduce treatment times. Recently, numerous methods have been proposed to enhance the rate of orthodontic tooth movement so that faster and better treatment options can be provided to the patients.

The present article aims to review the different Non Surgical and Surgical techniques which have been proposed to fasten the rate of orthodontic tooth movement.

2. NON-SURGICAL METHODS

2.1 Self-Ligating Bracket Design

Self-ligating brackets(SLB) were initially intended to save time during an era when an arch wires were tied into the brackets with steel ligatures. Over for the last 20 years, SLB have undergone a re-emergence with more user-

friendly appliance designs.

The first retrospective clinical studies on treatment efficiency was in year 2001 supporting the finding of shorter treatment times^{2,3}. The studies were retrospective in design with the inherent flaws and risks of bias.

The first prospective clinical trials did not appear until 4-5 years later and have found no difference in treatment effect.^{4, 5} Two systematic reviews concluded that there was no difference between conventional brackets and SL brackets in treatment time or the number of visits required.^{6,7}

Self-ligating brackets with its advantage of self lock provides low friction with good arch wire control making it virtually easier to align the crowded arches without extractions. The reason for extraction is correspondingly reduced thereby the treatment is shortened by about 3-4 months as compared to the conventional method which includes extraction for correction of malocclusion.⁸

2.2. Medication

A variety of drugs have been used since long to speed up the orthodontic tooth movement, and have achieved thriving results.⁹⁻¹¹ The drugs include vitamin D, prostaglandin, interleukins, parathyroid hormone, misoprostol to name a few.

Sadly, much of the data comes from animal studies rather than the human trials. In human



trials on investigating the application of prostaglandins on orthodontic tooth movement, the results have suggested a possible increase in tooth movement.¹²

But, all of these drugs have some or the other unreliable adverse effect. For example, vitamin D when injected in the periodontal ligament (PDL) increases the levels of Lactate Dehydrogenase (LDH) enzyme which is an inflammatory mediator and the prostaglandin which causes a widespread increase in the inflammatory state and by this means causing root resorption. Hence currently, no drug exists that can safely accelerate orthodontic tooth movement.

An additional projected option is the use of autologous platelet rich plasma (PRP) as an alternate for the local injection of cytokines or other medications to simulate the effects induced in bone during surgery.

Platelets are the initiator of soft and hard tissue wound healing processes and contain growth factors such as the Platelet Derived Growth Factor (PDGF), Transforming Growth Factor (TGF), and Endothelium Growth Factors(EGF) . The submucosal injection of PRP is a clinically feasible and an effective technique to accelerate the OTM and simultaneously preserve the alveolar bone on the pressure side of OTM, and the most favorable dose of PRP for the best clinical performance is 11.0–12.5 folds.¹³

2.3 Cyclic Forces (Vibration)

The principal behind the use of a cyclic vibratory method is to place light alternating forces on the teeth with the help of mechanical radiations.¹⁴ The cyclic loading was applied to the vibration group for 20min/day using the AcceleDent device (Figure1). AcceleDent, an FDA(United States Food and Drug Administration) -cleared Class II medical device, complements conventional fixed braces with compelling clinical results which delivered a force of 0.25 N (25g) at a frequency of 30Hz. These vibrations stimulated the remodeling activity and hence brought about tooth movement at the rate of 2-3 mm/month. These devices are portable so they can be charged as similar to any other electronic device. Various

case studies using this device have shown that orthodontic treatment time could be reduced by up to 30-40 %.¹⁵

To discover the clinical effects of AcceleDent device, Kau et al conducted a clinical trial in which 14 orthodontic patients were recruited and were instructed to use the device for 20 minutes daily for a period of 6 consecutive months. In the result, it was found that the total rate of movement in the mandibular arch was 2.1 mm per month and for the maxillary arch was 3.0 mm per month, which in fact is faster than the traditional finding of about 1.0 mm per month.¹⁵

2.4 Pulsed Electromagnetic Fields

Currently there is one clinical trial which studied the effect of the pulsed electromagnetic fields on tooth movement in ten subjects. Although an increase in tooth movement rate of 0.3 mm/month was reported when using the pulsed electromagnetic fields, this study was poorly conducted and carried at a high risk of bias. Considering its unreliable methodology and also its reporting, the effectiveness of pulsed electromagnetic fields on the acceleration of orthodontic tooth movement cannot be determined.^{16, 17}



Fig. 1 AcceleDent: Device with vibratory forces for accelerating tooth movement

2.5 Direct Electrical Currents

There have been experiments that were conducted on cats which has reported a possible increase in OTM with the use of locally applied electric currents.

Procedure: An electric appliance that provides



direct electric current was placed in the region of extracted tooth, this generated bio electric potentials causing local responses and thus acceleration of bone modeling.

In a split-mouth study in seven cats which measured canine retraction by applying an electric current of 20 μ A for five hours daily, the distance moved of the canine was 30 percent greater on the experimental side after one month when compared with the control side. (2.42 +/- 0.26 mm vs. 1.89 +/- 0.27 mm).¹⁸

Subsequently on human trials as well, Kim found 30% acceleration of orthodontic tooth movement when compared to the conventional technique without using the electric currents.

In the literature, only three studies have been reported on the use of this technique in the literature of which two were animal studies and one was on humans. Currently there is limited evidence on the use of this method and further research is required to determine if there will be clinical application of the same.¹⁹

2.6 Low-Level Laser Therapy

Low-level laser therapy (LLLT) is one of the potential approaches today for the increase in OTM. Laser has a biostimulatory effect on bone regeneration which is seen in the midpalatal suture during rapid palatal expansion of the maxilla.

The mechanism involved in this method is the production of ATP and activation of cytochrome C. The LLLT enhances the velocity of tooth movement via RANK/RANKL with the macrophage colony-stimulating factor and receptor expression.²⁰

In the year 2004, Cruz et al was the first person to perform a human study on the effect of low-intensity laser therapy on OTM using Gallium Aluminum Arsenide diode laser. Hence the authors came to a conclusion that the irradiated canines were retracted at a rate 34% greater than the control canines over a period of 60 days during the period of retraction.²¹

There are a lot of contradictory results related to the studies conducted on the use of LLLT on

tooth movement. Therefore, more research is needed in order to differentiate the optimum energy, wavelength and the optimum duration for its usage.²²

2.7 Photobiomodulation (PBM)

Photobiomodulation (PBM) uses low energy lasers (previously discussed) or the light-emitting diodes (LED) to modify cellular biology by exposure to the light in the red to near-infrared range (600–1000 nm).

The evidence regarding the use of PBM is limited to one trial that was done using the OrthoPulse™ appliance (Figure 2) which was conducted by a consulting orthodontist for the company Biolux Research Ltd. This study hence draws a conclusion that intraoral PBM increases the average rate of tooth movement with a 54 percent average decrease in the alignment duration as compared to the control. However, there were many confounding variables including the use of different brackets in the two test groups.

Of the many shortcomings of the study, some included the study design to be poor, lacking appropriate and complete reporting of the results, thereby the overall quality of evidence supporting this intervention is currently very low.²³

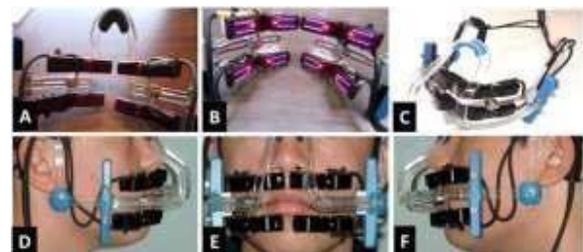


Fig. 2 OrthoPulse™- Device for Photobiomodulation (PBM)

3. SURGICAL APPROACH

Several surgical approaches that have been tried in order to accelerate tooth movement are Corticotomy, Wilckodontics, Micro Osteo



Perforation, Distraction, Piezocision technique and Surgery First approach. The idea of surgical acceleration came into being after the introduction of Regional Acceleratory Phenomena (RAP) by Frost in 1983.

RAP is a local response to noxious stimulus, by which tissue forms faster than the normal regional regeneration process. This phenomenon causes healing to occur 2–10 times faster than normal physiologic healing by enhancing the various healing stages

3.1 Corticotomy

The regular corticotomy technique includes rise of full thickness mucoperiosteal folds, buccally as well as lingually, trailed by putting the corticotomy cuts utilizing either micromotor under water system, or piezosurgical instruments. This can be succeed by position of a graft material, where it is needed, to increase thickness of bone. It is first portrayed by Kole in 1959²⁴, He detailed that consolidating orthodontics with corticotomy prompted dynamic tooth movement in orthodontic cases in 6 to 12 wk. The technique was initially known as bony block

Fischer et al evaluated the treatment outcome of corticotomy using six patients presenting with bilaterally impacted upper canines. as part of the treatment canine on one side was exposed using a normal surgical technique, while the canine on the other side of the arch was exposed using a corticotomy-assisted procedure. The overall results presented a reduction in total treatment time of 28%-33% for the canine treated with corticotomy.²⁵

Aboul-Ela et al assessed 13 individuals who had undergone the therapeutic extraction of the maxillary first premolars, after the extraction procedure, retraction of the maxillary canines was also done. Corticotomy-encouraged orthodontics was given to the one side of the maxillary arch which was randomly selected, and the opposite side filled in as control side. it was noticed that the normal per day retraction of canine was altogether increased on the corticotomy side, it was twice that of the control side amid the initial 2 months after corticotomy.²⁶

Shoreibah et al directed an examination to assess the impact of corticotomy facilitated orthodontics (CFO) in adult patients utilizing a further adjusted procedure versus traditional treatment in orthodontic tooth movement.

The authors demonstrated a statistically significant contrast between the both the groups in regards to orthodontic treatment time: 17 week in the Corticotomy Facilitated Orthodontic gathering and 49 week in the regular orthodontic therapy group.²⁷

3.2 Wilckodontics

Wilcko siblings presented a corticotomy encouraged procedure including alveolar augmentation. The procedure incorporates labial and lingual alveolar flaps done with constrained selective corticotomy. As indicated by Wilcko et al, the quickened tooth movement in corticotomy is because of an increased rate of bone turnover and diminished bone thickness. At the point when a tooth retract through a repairing Surgical site, the tensional stress on the teeth cause a synergistic way with growth factors to reclassify nearby bone mass.²⁸

3.3 Piezocision

Piezocision was presented by Dibart et al in 2010. It presented as an insignificantly invasive, flapless strategy consolidating piezo surgical cortical microincision cuts along with specific tunneling that gives a way for grafting of bone or any soft tissue. Because of its little size and accuracy, piezoelectric supplements acknowledge exact osteotomies with no complications of osteonecrosis. The creators excised the lingual flap by doing just vestibular cuts, however raising the flap before the corticotomy procedure was continued, subsequently moderately lessening surgical time and postoperative inconvenience.²⁹

Uribe et al noticed that corticotomies can possibly decrease the treatment time drastically in patients who require a lot of molar protraction. The authors detailed a solitary case, of a patient with agenesis of the lower second premolars, after the extraction of deciduous second molars, mucoperiosteal folds were raised and



interproximal vertical corticotomies were done on the labial part of the mandibular molars using a piezo surgical micro saw. The vertical notch corticotomies were performed mesial to the first and second molars on both sides and broadened just underneath the crestal bone till the apex. Dried-freeze demineralized bone allograft was stuffed on the buccal surface covering the sectional grooves and uncovered labial cortical bone surface, including a dehiscence which was present on the first molar. The edentulous area was closed by protracted first molar in the span of ten months.³⁰

3.4 Dentoalveolar Distraction

Dentoalveolar distraction (DAD) is done by performing monocortical apertures on alveolar bones circumscribing the canines, trailed by distracting the cuspid utilizing distractors.

As per Işeri et al the dentoalveolar distraction procedure is a creative strategy that lessens general treatment time by about half. The creators directed an examination that comprised of 20 maxillary canines in 10 subjects, the first premolars were extracted, the dentoalveolar distraction surgery was played out, The canines are moved quickly into the edentulous areas in 8 to 14 days, at a speed of 0.8 mm for every day and complete retraction of the canines was accomplished in an interim of 10 days.³¹

Kurt et al revealed a 15-year-old skeletal as well as dental class-2 girl patient, having increased overjet of 9 mm who was dealt with by Dento alveolar distraction osteogenesis. A uniquely designed, inflexible, tooth-supported intraoral distraction appliance was utilized for fast canine movement. Osteotomies encompassing the canines are performed to accomplish fast retraction of the canines inside the alveolar bone, in consistence with distraction osteogenesis standards. The measure of canine movement was 7.5 mm in twelve days achieving the speed of 0.625 mm for each day.³²

3.5 Periodontal Distraction

The Periodontal distraction is done by making vertical scores on the mesial side of the first premolar extraction socket took after by asimilar

distraction procedures utilized as a part of Dento Alveolar Distraction (DAD).

Gürkan et al in 2005, amid an a year follow-up time, however with no control group , examined 36 upper canines until the point that complete retraction of the canines was accomplished in 10 days at a speed of 0.8 mm/day utilizing specially crafted intraoral inflexible tooth-supported distraction gadget.³³

Sukurica et al in a 6-month after treatment examination, assessed 20 canine retraction in 8 individuals. The distraction technique was finished in twelve to twenty eight days. The distal movement of the canines was noted as 3 to 8 mm.³⁴

Kumar et al presumed that canines could be quickly retracted by PDL distraction with no further problems. The examination was completed in sixteen maxillary canines in 8 patients who was in need of first premolar extractions. Custom-assembled distractors were set and initiated quickly to occupy the canines to the space created by extraction. The canines achieved complete retraction within 20 days.³⁵

3.6 Monocortical Tooth Dislocation and Ligament Distraction (MTDLD)

Vercellotti et al , built up a surgical-orthodontic strategy to amplify the velocity of tooth movement and counteract harm to the PDL . Amid the procedure they played out a microsurgical corticotomy circumscribing every tooth, buccal monocortical tooth disengagement and distraction of palatal ligament and applying the biomechanical force immediately. They inferred that contrasted with conventional orthodontic treatment, the normal span of treatment with MTDLD system in the maxilla and mandible was decreased by 70% an 60%, separately.

In 2011, Bertossi et al done piezosurgical bone slices to ten individuals influenced by various dental deformities to decide the impacts of a lesser orthodontic treatment time. This MTDLD system is straightforward, and executing osteotomic cuts horizontally and apically to the tooth root on the bone has demonstrated valuable



in diminishing the time span of treatment. In five patients with dental ankylosis, dental repositioning was accomplished in a duration of 18 to 25 days and in another five preoperative patients caused by maxillary hypoplasia and decreased measurement of transverse maxilla, in 68 to 150 days.³⁷

In 2010, Kharkar et al led a non-randomized study. The point of this investigation was to survey and assess the best way to deal with diminish the general treatment time by methods of distraction osteogenesis. Authors presumed that the dentoalveolar distraction was better than periodontal distraction in the time required for retraction, tipping of canine, loss of anchorage, measure of external root resorption.³⁸

3.7 Microosteoperforation [MOPs]

This approach will invigorate the outflow of inflammatory markers prompting increment in osteoclast action and the rate of tooth movement. Specifically, by expanding the nearby levels of cytokine action around a tooth, the speed of tooth movement amid Orthodontic treatment can be increased. It makes unsurprising Orthodontic treatment outcomes, enhances finishing and lessens or dispenses with refinements with clear aligner treatment.

"Teixeira et al presented microosteoperforation in orthodontics . PROPEL System was composed and developed particularly to boost the alveolar bone remodeling impact while giving a simple and straightforward gadget that can be utilized by any clinician. The treatment edge of the PROPEL gadget is made of solidified hardened stainless steel and intended to ensure the integrity of the bone.³⁹

Mani Alikhani et al (2013) played out a solitary focus single blinded examination to research this methodology on people. He found that microosteoperforations altogether increased the outflow of cytokines and chemokines which are known to enlist osteoclast antecedents and fortify osteoclast differentiation. MOPs increased the speed of canine retraction 2.3-times contrasted with the control group.⁴⁰

3.8 Surgery First Approach

The execution of surgery without orthodontic planning, trailed by normal post-surgical dental arrangement, was given by Nagasaka et al. They utilized this way to deal with correction of skeletal class-3 malocclusion along with guide of skeletal anchorage. The aggregate treatment span was detectably lessened.⁴¹

As indicated by Liou et al, the benefits of the surgery-first procedure are as per the following: (1) the patient's main grievance, functional stability, and facial aesthetics are accomplished and enhanced toward the start of therapy; (2) the whole treatment time frame is abbreviated to one to one and half years or less relying upon the intricacy of the orthodontic therapy; and (3) the marvel of postoperative quickened orthodontic tooth movement diminishes the trouble and treatment duration of orthodontic therapy in the surgery-first technique. The criteria that are proposed for Surgery First Approach are: Well-adjusted to least crowding, Flat to gentle bend of Spee, Normal to very mild proclination/retroclination of incisors, minimal transverse inconsistency and contraindicated in quiet who require distinct decompensation, severe crowding, maxillary and mandibular arch incoordination, extreme vertical or transverse problems, and extreme proclination of upper and lower anterior regions.⁴²

The most normally announced disadvantages incorporate (1) Since the occlusion cannot guide treatment outcome and can't manage treatment objectives, clinical expertise, accurate expectation of postoperative tooth movement, and exact evaluation of the skeletal error are required. (2) The degree of surgical movements might be more noteworthy on the grounds that surgical amendment needs to represent dental compensation

(3) Postsurgical unsteadiness amid bone recuperating may cause skeletal instability, and its impact in relapse has not yet been completely examined.[43]

4. CONCLUSION

Tooth acceleration phenomenon is still a



relatively new horizon and researchers have yet to seek a single most ideal and prudent technique for the patient. The surgical techniques have most of the human trials and also show very favorable and long term effects adding 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. The recent methods such as lasers and mechanical vibration have reduced or eliminated the invasive nature of prior procedures used to accomplish the Regional Acceleratory Phenomenon. Further explorations in this field of non invasive therapies would prove to be beneficial for both the clinicians and the patients.

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