International Journal of Research in Health and Allied Sciences

Journal home page: www.ijrhas.com

Official Publication of "Society for Scientific Research and Studies" [Regd.]

ISSN: 2455-7803

Review Article

DEVICES FOR ACCELERATED ORTHODONTICS

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ABSTRACT:

Orthodontics which has long been known as a technique-oriented discipline has evolved into a comprehensive specialty that integrates all aspects of medicine. The objectives of orthodontic treatment must include good facial esthetics, adequate function as well as stability in the ultimate positions of the dentition and jaws. However, the patient's primary concern is the treatment duration. The past decade has been a surge in innovations pertaining to the field of orthodontics aimed at shortening the length of the treatment for adult patients. To date, several new modalities have been reported to accelerate orthodontic tooth movement including micro-osteoperforation, LLLT, AcceleDent, OrthoPulse. Despite advancements in various fields of orthodontics, accelerated tooth movement remains a topic of academic interest for research.

Keywords: Treatment duration, micro-osteoperforation, LLLT, AcceleDent, OrthoPulse and accelerated tooth movement.

Received: 19 January, 2022 Accepted: 27 February, 2022

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This article may be cited as: Kaur K, Munjal S, Singh S, Singh H, Jeeboy S. Devices For Accelerated Orthodontics. Int J Res Health Allied Sci 2022; 8(2): 90- 97.

INTRODUCTION

Comprehensive fixed appliance orthodontic treatment usually takes around two to three years to complete. Since long treatment period is one of the major drawbacks in orthodontics as there are chances of increased periodontal insult, decalcification, dental caries and root resorption. Therefore, shortening the orthodontic treatment time by increasing the rate of tooth movement is an effective way to minimize the exposure of patients to risks associated with treatment and related costs and can improve patient satisfaction.[12]

HISTORICAL BACKGROUND

Over the past century, different techniques of surgical intervention to influence the alveolar housing and hence tooth movement have been identified. Since the 1800s, surgical approach for orthodontic tooth movement (OTM) had been used. Bryan documented the first corticotomy-assisted tooth movement in a textbook called "Orthodontia: or Malposition of the Human Teeth, Its Prevention and Remedy" published by Guilford in 1893. During the same year, Cunningham illustrated "Luxation, or the Immediate Method in the Treatment of Irregular Teeth" at the International Dental Congress in Chicago. In 1931, Bichlmayr pioneered a surgical approach alongwith orthodontic appliances for rapid correction of severe maxillary protrusion.[8] Since then various techniques had been introduced for accelerating the tooth movement which can be summarized as depicted in Table 1.

S.NO	TECHNIQUE	YEAR	AUTHOR
1.	Corticotomy	1959	Kole
2.	Use of Prostaglandins (Rats)	1980	Yamasaki
3.	Direct electric current stimulation	1980	Davidovitch
4.	Use of Prostaglandins (Humans)	1984	Yamasaki
5.	Fiberotomy	1986	Tuncay and Killiamy
6.	Local use of Vitamin D	1988	Collins
7.	Dental distraction	1998	Liou and Huang
8.	Parathyroid hormone	1999	Soma
9.	PAOO	2001	Wilcko
10.	Use of relaxin	2005	Lui
11.	RANKL gene therapy	2006	Kanazaki
12.	Resonance Vibration	2008	Nishimura
13.	Corticision	2009	Kim
14.	Piezocision	2009	Dibart
15.	Pulsed Electromagnetic field	2010	Showkatbaksh
16.	Micro-osteoperforation	2010	Teixeira
17.	Platelet rich plasma	2016	Liou

TABLE 1 Summary of different approaches for accelerating tooth movement

CLASSIFICATION OF METHODS OF ACCELERATING TOOTH MOVEMENT

Various classification for methods of accelerating the tooth movement have been described as below-

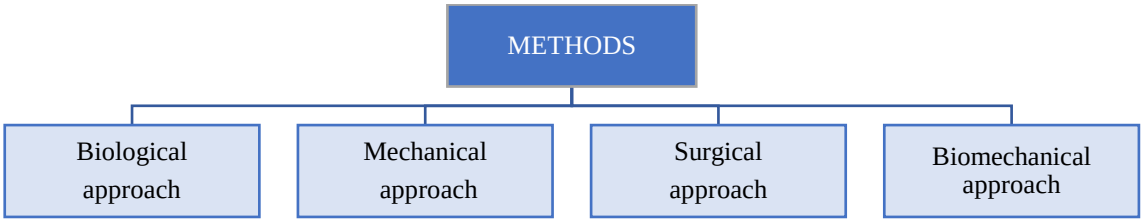
[A] According to C.C. Teixeira, Edmund Khoo and Mani Alikhani, the different methods of accelerating tooth movement can be classified as[1] –

STIMULATING THE ARTIFICAL PATHWAY TO INCREASE THE RATE OF TOOTH MOVEMENT	STIMULATING THE NATURAL PATHWAY TO INCREASE THE RATE OF TOOTH MOVEMENT
Chemical Agents • Parathyroid Hormone • Thyroxin • Relaxin • Vitamin D_3 • Osteocalcin • Corticosteroids Physical Stimulation • Mechanical Stimulus/Vibrations • Electric Currents • Low Level Laser Therapy	• Corticotomy • Piezoincision • Micro-osteoperforations

[B] On the basis of the level of invasiveness, the methods of accelerating orthodontic treatment can be broadly classified into[14] –

INVASIVE PROCEDURES	MICRO-INVASIVE PROCEDURES	NON-INVASIVE PROCEDURES
• Corticotomy • Periodontally Accelerated Osteogenic Orthodontics (PAOO)	• Corticison • Piezocision • Micro-osteoperforation	• Low level laser therapy (LLLT) • Vibration • Drugs • Platelet Rich Plasma

[C] Methods to accelerate orthodontic tooth movement can be broadly categorized into[11]-



[D] Methods for accelerating orthodontic tooth movement can be also be categorized into[9] –

CONSERVATIVE METHODS/NON-SURGICAL METHODS	SURGICAL METHODS
Pharmacological agents • Growth hormone • Parathormone (PTH) • Vitamin D • Thyroxine • Beta 2-adrenergic agonist Physical stimuli • Electromagnetic Fields • Vibrations • Photobiomodulation • Low Level Laser Therapy (LLLT) Self- Ligating brackets	• Corticotomy • Periodontally Accelerated Osteogenic Orthodontics (PAOO) • Piezocision • Micro-osteoperforation

VARIOUS DEVICES USED FOR ACCELERATING ORTHODONTIC TOOTH MOVEMENT

At present, there are a number of commercial devices designed for accelerating orthodontic tooth movement. Among these are -

1. Tooth Masseuse
2. AcceleDent Type 1
3. AcceleDent Aura
4. AcceleDent Optima
5. Low Level Laser Therapy (LLLT)
6. Extra-oral OrthoPulse
7. OrthoPulse™
8. OrthoPulse
9. Micro-osteoperforation

1. TOOTH MASSEUSE

Tooth masseuse is a vibrational appliance that provides a vibrational frequency of 111 Hz and a force of 0.06 N (Figure 1). It requires the patient to gently bite onto a vibrating thermoplastic wafer, which is in contact with the occlusal surface of the maxillary and mandibular dentitions. It is recommended that subjects should use them for around 20 min/day as a supplement to their fixed appliance treatment. There is limited evidence with regard to the clinical efficiency of these devices.[10]

FIGURE 1 Tooth Masseuse

2. ACCELEDENT TYPE 1

The device is a removable orthodontic device similar to a retainer which delivers vibratory forces to the dentition.

The primary components of the device are -

(a) Activator
(b) Mouthpiece

This device generates cyclic forces to move teeth in bone faster through rapid bone remodeling. The mouthpiece is made of polyurethane over-molded onto a metal base. The study activator (7.5 oz vibrating device) consists of a molded hard plastic covering that houses a lithium ion battery, motor, microprocessor and weights. The two weights are rotated by the motor, which generates vibration at settings of 30 Hz, 20g (0.2 N) for 20 minutes. After activating the device, the patient chews on the mouthpiece and the activator, which is positioned just outside the mouth, generates and transfers the vibration to the teeth (Figure 2).[6]

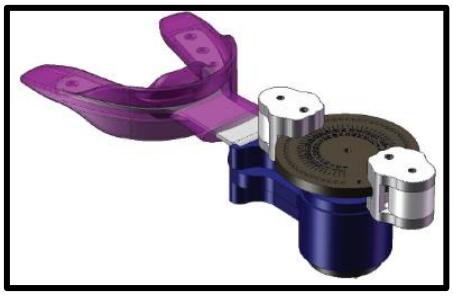


FIGURE 2 AcceleDent Type 1

3. ACCELEDENT ® AURA

The device consists of four parts -

(i) Activator: which generates micro pulses/ vibrations
(ii) Mouthpiece: which is held between the two arches. It comes in different sizes for different arch forms.
(iii) Travel shell: used to store the device after use.
(iv) Charging port: used for electrical charging of the device.

AcceleDent ® is a hands-free device consisting of an activator unit and removable mouthpiece which provides a vibrational frequency of 30 Hz and a force of 0.2 N. The orthodontist prescribes the device for home use. It can be used in conjunction with any orthodontic treatment, including braces or clear aligners. It should only be used by one patient and should be discarded once the treatment is complete. During orthodontic treatment, the patient activates the activator and bites on the mouthpiece for 20 minutes every day. The device is light in weight and should only be held in place with gentle bite pressure (Figure 3).[3]

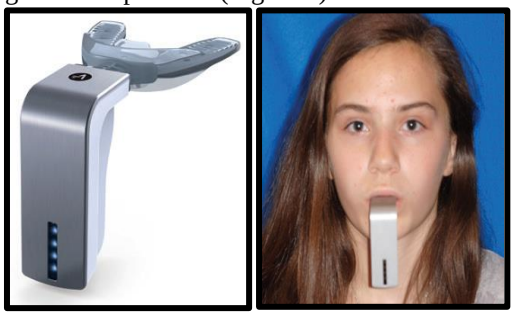


FIGURE 3 [A] AcceleDent activator and [B] AcceleDent device in use

4. ACCELEDENT OPTIMA™

Acceledent Optima™ is a strategic, technology-driven tool for orthodontists which helps to achieve high-quality clinical results and is manufactured by OrthoAccel Technologies. It uses soft pulse technology which utilizes the calibrations or micro-pulses that are transmitted to the roots of the teeth and to the surrounding bone. These vibrations further increase the activity on the cellular level which leads to rapid tooth movement. The force used by the device is up to 8 times less force than a power toothbrush and 200 times less force than chewing. (Figure 4)
It is a hands-free orthodontic mouthpiece that has been clinically shown to accelerate tooth movement upto 50% faster. It is the first orthodontic device of its kind to offer accelerated orthodontic treatment and helps to decrease the orthodontic discomfort in a non-invasive, non-surgical way. It can be used with both braces and Invisalign™ and is FDA approved. It is the first and only accelerated orthodontic device that connects patients and practices with an app to monitor use and direct messaging.

FIGURE 4 AcceleDent Optima™

5. LOW LEVEL LASER THERAPY (LLLT)

Photobiomodulation or LLLT is a physical method of accelerating tooth movement, which has gained wide acceptance due to its non-invasive nature. The major components of an LLLT system are the laser device, a delivery system and a controller. (Figure 5). The mechanism involved in the acceleration of tooth movement is by the production of ATP and activation of cytochrome C-oxidase which was seen when low energy laser irradiation enhanced the velocity of tooth movement via RANK/RANKL and the macrophage colony-stimulating factor and its receptor expression. It has been found that laser light stimulates the proliferation of osteoclast, osteoblast, and fibroblasts and thereby affects bone remodeling and accelerates tooth movement.[2]

FIGURE 5 LLLT Unit

6. EXTRA-ORAL ORTHOPULSE DEVICE

Extra-oral OrthoPulse device produced near infrared light with a continuous 850-nm wavelength. The surface of the cheek was irradiated with a power density of 60 mW/cm^2 for 20 or 30 min/day or 60 min/week to achieve total energy densities of 72, 108 or 216 J/cm^2 respectively. Light emitting diodes (LEDs) were used to produce the light with arrays of emitters arranged in a series of treatment arrays to cover the target area of the alveolus of both the maxilla and mandible.

The device consists of three main components -

1. A small handheld controller which houses the microprocessor, the menu-driven software, and the LCD screen. The controller is programmable by the investigator for the number of treatment sessions and the session duration. The user interface indicates to the patient the number of sessions completed and the remaining time in each session. The controller plugs into the power mains via a medically approved, UL-certified power supply.
2. A set of four extra-oral treatment arrays, each with a flexible printed circuit board and a set of LEDs mounted on a contoured heat sink and infrared transmissible plastic lens, with conductive cables to the controller. (Figure 6 A, B)
3. A headset similar to an eyeglass support structure to be worn by the patient on a daily or weekly basis, with attachment and adjustment mechanisms to position the treatment arrays in the appropriate location for the given patient.[7] (Figure 6 C)

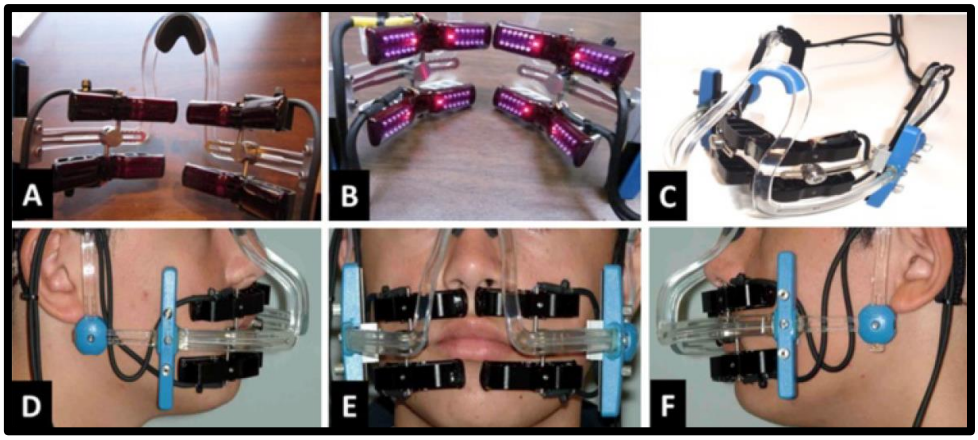


FIGURE 6 Extra-oral OrthoPulse device

7. ORTHOPULSE™

This consists of an intraoral appliance connected to a handheld controller (Figure 7). The controller houses the microprocessor, LCD screen and controls for the menu-driven software. The mouthpiece is formed from a flexible circuit of LED arrays embedded in medical grade silicone. The light is delivered into the alveolus through the buccal alveolar soft tissue.[13]

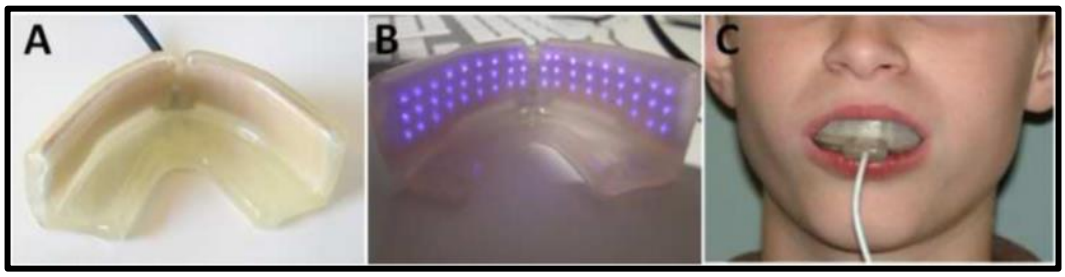


FIGURE 7 OrthoPulse™

8. ORTHOPULSE

This is an established device that uses low levels of light energy to stimulate the bone surrounding the roots of the teeth which may reduce treatment duration. The OrthoPulse device is designed to accelerate the orthodontic tooth movement and reduces the overall treatment time for the patient. It is the first device approved by the US FDA for use with both in traditional orthodontic treatment with brackets and wires or aligners. To accelerate tooth movement, this device employs continuous 850nm-wavelength light. It is wireless, made of medical-grade silicone and embedded with flex circuit arrays of LEDs. Patients can easily complete daily treatments at their convenience by using a portable handheld device. This device also has a built-in bluetooth to transmit usage data to the smartphone application.[4] (Figure 8).

FIGURE 8 OrthoPulse

9. MICRO-OSTEOPERFORATION

Propel Orthodontics introduced a device called Propel to reduce the invasive nature of surgical bone irritation. The Consortium for Translational Orthodontic Research pioneered the concept of Micro-osteoperforation (CTOR).

It is a safe, minimally invasive procedure and involves controlled micro trauma to the bone by means of micro-osteoperforations. It is based on the premise that micro trauma to the bone increases the expression of cytokines and chemokines that are usually released due to orthodontic forces. This leads to an increased number of osteoclasts. Thus, bone density decreases and bone resorption increases which causes rapid tooth movement.

This device comes as ready-to-use sterile disposable device. This device is a handheld device (Figure 9, 10) used to make small perforations in the cortical bone. The device has an adjustable depth dial and indicating arrow on the driver body. Depending on the area of operation, the adjustable depth dial can be set to 0 mm, 3 mm, 5 mm, or 7 mm of tip depth.[1,5]

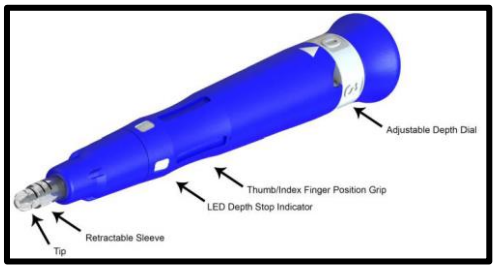


FIGURE 9 The PROPEL device

FIGURE 10 Application of micro-osteoperforations

CLINICAL APPLICATIONS FOR THE FUTURE

The concept of accelerating the orthodontic tooth movement has been gaining importance in the recent years. Lot of techniques have been proposed till now. The surgical techniques have demonstrated more favorable and long-term effects which further enhanced the stability and retention of the orthodontic therapy. However, the invasiveness and cost of these might make it a little less viable option for the patients. To accelerate tooth movement, less invasive surgical techniques can be employed since there is increased patient compliance. Device assisted therapy is also of high demand but more research is needed to determine the best device to utilise and how effective it is.

Today newer orthodontic devices such as Propel and AcceleDent when used in conjunction with orthodontic therapy have shown promising results in accelerating OTM with least discomfort. Yet, more research is necessary to substantiate claims, enhance technology and techniques in the field of orthodontics. In general, all these techniques had some drawbacks and uncertainties.[15]

CONCLUSION

At present, various recent methods such as micro-osteoperforations, lasers, LED and mechanical vibrations have reduced or eliminated the invasive nature of prior procedures used to accomplish the Regional Acceleratory Phenomenon. Further clinical research is required to investigate and safely approve a particular method of accelerating orthodontic tooth movement.

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