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Accelerated Tooth Movement Surgical VS Non-surgical Approach

A Project Submitted to

The College of Dentistry, University of Baghdad, Department of Orthodontics in Partial Fulfillment for the Bachelor of Dental Surgery

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Certification of the Supervisor

I certify that this project entitled **" Accelerated Tooth Movement Surgical VS Non-surgical Approach"** was prepared by the fifth-year student **Zahraa Abbas Fadhil** under my supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.

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Date : **MAY, 2023**

Dedication

I dedicate my project to my **Mother and Father** for their endless love, support and encouragement throughout my pursuit for education.
to my **brother and sister** who have been my source of inspiration and gave me strength when i thought of giving up and lastly I dedicated this project to my **close friends** who have always supported me throughout my years of study .

Zahraa abbas fadhil

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Finally, I offer my regards and blessing to my family for their support and encouragement.

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COR	Center of rotation.
COX	Cyclooxygenase.
EGG	Epidermal growth factor .
LLLT	Low lazer level Therapy .
MOPs	Micro-osteoperforations.
OC	Osteocalcin.
OTM	Orthodontic tooth movement .
PDL	Periodontal ligament .
PGE	Prostaglandin.

PTH	Parathyroid hormone
RANKL	Receptor activator of nuclear factor kappa-B ligand.
RAP	Regional acceleratory phenomen.

Introduction

Moving teeth through the dentoalveolar complex is a synergistic sequence of physical phenomenon and biological tissue remodeling . Basically, tissue reactions observed in orthodontic tooth movement to some extent resemble that observed in physiologic tooth Migration **.** Because the teeth are moved more rapidly during treatment, the tissue changes elicited by orthodontic forces are more significant and extensive **(Garber, 2017).**

Most orthodontic treatments should not be started until the permanent canines and premolars have been erupted. At this age the response to orthodontic forces is more rapid. However, when the malocclusions are severe enough to be solved by orthodontic treatment, in these cases the treatment with fixed appliances is likely to last for 20 to 24 months. **(Akhare *et al*., 2011).**

The lengthy duration of orthodontic treatment is considered a major disadvantage. This may lead to loss of patient . Unfortunately, long orthodontic treatment time poses several disadvantages like higher predisposition to caries, gingival recession, and root resorption. This increases the demand to find the best method to increase tooth movement with the least possible disadvantages.there is an increased tendency for researches to focus on accelerating methods for tooth movement due to the huge demand for adults for a shorter orthodontic treatment time . **(Ghada *et al.,* 2013) .**

Accelerating orthodontic tooth movement has long been desired for its multiple potential benefits, including shorter treatment duration, reduced side effects (such as oral-hygiene related problems, root resorption, and open gingival embrasure spaces1-5), enhanced envelope of tooth movement, differential tooth movement, and improved posttreatment stability **(Huang *et al*., 2014)** . Reducing the treatment time requires increasing the rate of orthodontic tooth movement.Many studies have examined different methods that can increase the rate of orthodontic tooth movement including Nonsurgical methods, such as various physical and pharmacologic approaches, also enhance bone remodeling and facilitate tooth movement, and have been shown to be effective in animal and human experiments.

Surgical category includes Direct injury to the alveolar or basal bones of the maxilla and mandible accelerates orthodontic tooth movement by inducing RAP as a wound-healing process, which is the basis for clinical procedures such as corticotomy-assisted orthodontics, piezocision-aided orthodontics, and surgery-first orthodontics. The idea of surgically accelerated tooth movement although more than a century old has only gained momentum and interest during the past 10 years **(Shirude *et al.*, 2018)**

Aim of this study

1-The aim of this study to discuss the types of tooth movement accelerating techniques and their role in reducing the time of orthodontic movement, in addition to their side effect.

2- To review and highlight the successful techniques used for acceleration of orthodontic tooth movement.

3- To find the difference between surgical and non-surgical accelerated approach .

Chapter one

Review of literature

1.1) orthodontic tooth movement

Orthodontic tooth movement is the result of a biological response to interference in the physiological equilibrium of the dentofacial complex by an externally applied force **(Proffit, 2019)**. Orthodontic tooth movement is reliant on the activity of the bone cells (osteoclasts and osteoblasts) which are responsible for the bone resorption and deposition **(Littlewood, 2019)**

When force is applied to a tooth during orthodontic tooth movement, mechanical stress is loaded on the alveolar bone. Alveolar bone and the periodontal ligament (PDL) are compressed on one side, while on the opposite side, the PDL is stretched. The mechanical stress of the stretched PDL induces alveolar bone modeling (surface apposition of bone), while the mechanical compression produces bone remodeling (the turnover of bone in small packets **(Calogero et al., 2002)**

1.1.1)PHASES OF TOOTH MOVEMENT

Burstone categorized three distinct yet overlapping stages of tooth movement. They are:

1.1.1.1)Initial Phase :

The initial phase occurs immediately after the application of force onto the tooth. This results in rapid tooth movement over a short distance and then stops. This movement displaces the tooth within the periodontal membrane and bends the alveolar bone to a certain extent. The initial phase results in about 0.4 to 0.9 mm of tooth movement and usually occurs within a week after applying initial force **(Tanya, 2022)**.

1.1.1.2)Lag Phase :

Following the initial phase, there is a lag period in which there is a little or no tooth movement. Lag phase occurs due to the formation of hyalinization tissue in the periodontal ligament, which has to be eliminated before tooth movement can progress further **(Phularia, 2017)**. The duration of the lag phase depends on the amount of force applied. Supposedly a clinician applies lighter force, the amount of hyalinized tissue will be less; hence resorption of the same will occur faster. In contrast, a more prolonged lag phase is seen when heavier forces are applied orthodontically . The duration of the lag phase also depends on factors such as the patient's age , the density of the alveolar bone and Extent of hyalinization **(Tanya Prasad,2022).** The necrotic tissue are removed by macrophages, foreign body giant cells and osteoclast cells **(Asiry, 2018).** Generally, a lag period of 2–3 weeks is seen although it can extend for longer periods **(Phularia, 2017)**.

1.1.1.3) Post Lag Phase

After the resorption of the hyalinized tissue or the lag phase, tooth movement progresses rapidly. This occurs in the post-lag phase, where bone undergoes resorption via the help of osteoclasts, resulting in direct resorption of the bone that faces the periodontal ligament **(Tanya Prasad, 2022)** This phase seen after forty days after the initial application of the force **(Asiry, 2018).**

1.1.2)Theories of Orthodontic Tooth Movement

The mechanisms involved in conversion of orthodontic forces into biologic activity are not completely understood **(Sabane *et al.*, 2016).**

1.1.2.1) Pressure–tension theory

The histological research by **Sandstedt (1904)**, **Oppenheim (1911) and Schwarz (1932**), hypothesized that a tooth moves in the periodontal space by creating a pressure and tension side . When a force is placed on a tooth, bone is deposited on the tension side of the periodontal ligament and resorbed on the pressure side . On the pressure side, when the force is light, multinucleate cells resorb bone directly.However, if the forces are greater and exceed capillary blood pressure, cell death can occur and a cell-free area forms **(Saudi, 2018)** . This is described as hyalinization, due to the glass-like appearance of these regions when viewed with light microscopy resembling hyaline cartilage. Resorption of hyalinized areas proceeds at a much reduced rate. This process is described as undermining resorption and will result in slower tooth movement and greater pain and discomfort for the patient **(Cobourne, 2016)**.

1.1.2.2) Bone-bending theory

Farrar (1888) stated that when an orthodontic force is applied to the tooth, it is transmitted to all tissues near the area of force application. These forces bend bone, tooth and the solid structures of periodontal ligament **(Kashyap *et al*., 2016)**. Since the bone is more elastic than the other structures it bends effortlessly and the process of tooth movement gets accelerated. This also explains the rapid tooth movement occurring at the extraction site and in pediatric patients, in which the bone is not heavily calcified and is more flexible**(Saudi, 2018).**

1.1.2.3) Biological electricity theory

This theory was proposed by **Bassett and Becker in 1962**. According to them, whenever the alveolar bone flexes or bends it releases electric signals and to some extent is responsible for tooth movement. Initially it was thought to be piezo-electric signals. The characteristic of these signals are **(Profit, 2012):**

1. They have a quick decay rate which means it is initiated when the force is applied and at the same time it disappears quickly even with the force maintained.

2.They produce equal signal on the opposite side when the force is released .

After the bone bend, the ions interact with each other in the presence of the electric field causing electric signals and temperature change. A small voltage is observed called as “streaming potential”. They are different from piezoelectric signals and they even can be generated by external electric field, which can modify the cellular activity. There is another type of signal present in bone that is not being stressed called as “bioelectric potential”. The bone which is metabolically active shows electronegative changes that are proportional to its activity **(Sabane *et al*., 2016)**.

1.1.3) Types of Orthodontic Tooth Movement

The primary motive of orthodontic treatment is to move teeth into more favorable and corrected positions for better aesthetics and functionality. This process can involve the movement of teeth in all three planes; sagittal, coronal, and transverse. Various types of tooth movements can occur during the process of orthodontic treatment, such as:

1.1.3.1)Tipping

Tipping is the simplest type of tooth movement that occurs when a single force is applied to the crown of a tooth. Controlled tipping allows a unidirectional crown movement while the root moves minimally in the opposite direction(**Tanya, 2022)** occurs when the center of rotation is at the root apex **(Phularia , 2016).** In contrast, uncontrolled tipping tips the crown in the direction of the force while the root moves in the opposing direction **(Tanya, 2022) .** It moves about a center of rotation, which is between the center of resistance and the root apex(figure 1.1) **(Phularia, 2016).**

1.1.3.2) Bodily movement

Bodily movement or translation of teeth occurs when the crown with the root moves an equal distance in the same direction equally (figure 1.1,B)**(littlewood, 2019)** . This happens when the applied force passes through a tooth's center of resistance (COR). The COR of a single-rooted tooth lies between one-third and one-half of the root, while in a multi-rooted tooth, it lies between the roots. **(Tanya, 2022) .**

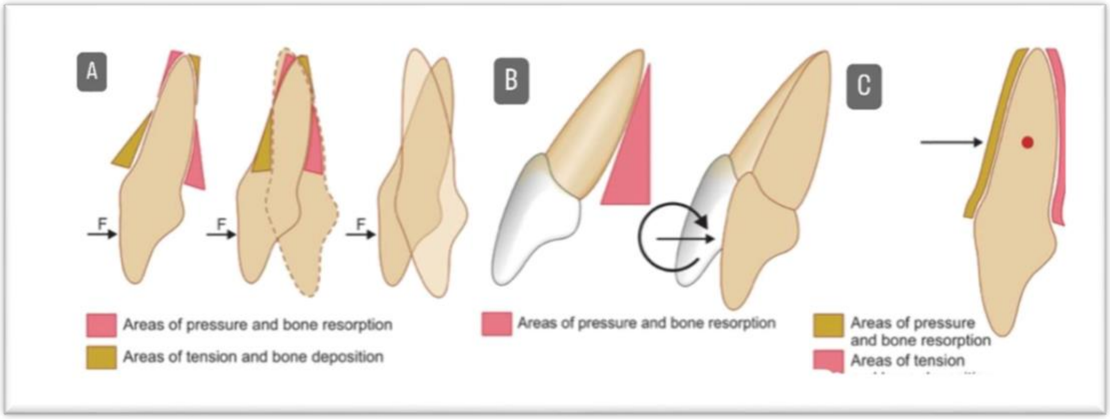

Fig 1.1 **:** types of tooth movement A) Uncontrolled tipping. Stresses in the periodontal ligaments are concentrated near the apex and cervical ; B) Controlled tipping C) : Bodily movement of the tooth **(Phularia, 2017)**

1.1.3.3) Intrusion and Extrusion

Intrusion occurs when a tooth bodily moves along its long axis in an apical direction (towards the gingiva) **(Tanya, 2022)** . Intrusion of the tooth involves resorption of bone, particularly around the apex of the tooth **(Phularia , 2016)** . In contrast, extrusion is the bodily movement of a tooth along its long axis towards the occlusal plane **(Tanya, 2022)** . Extrusion of the teeth from its socket can be achieved without much resorption of bone, bone deposition being required to reform the supporting mechanism of the tooth**(Phularia, 2016).**

1.1.3.4) Rotation

Orthodontic correction involves correcting rotated teeth and getting them into the correct alignment. Rotation of a tooth creates two pressure sides and two tension

sides. This occurs through rotational tooth movement, allowing teeth to move labially or lingually/palatally around their long axis **(Tanya, 2022)** Rotational movement occurs when a force is applied mesially and distally to the labial aspect of a tooth **(Littlewood, 2019).**

1.1.3.5) Torquing

Torquing tooth movement allows orthodontists control over the axial inclinations of the teeth. It can also be considered reverse tipping, characterized by the lingual movement of the root **(Tanya Prasad, 2022) .**

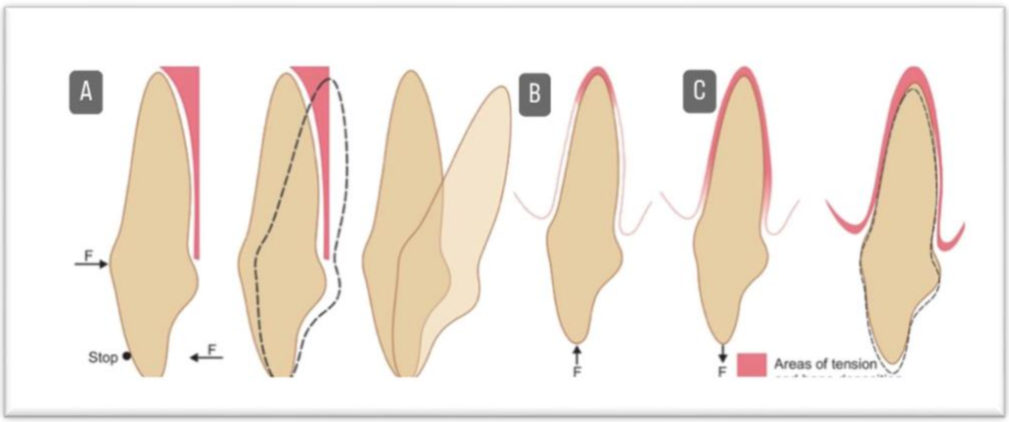

Fig 1.2 : types of tooth movement A) Root torque ; B) Intrusive tooth movement ; C) Extrusive tooth movement **(Phularia , 2017)**

1.1.4)Rate of orthodontic tooth movement :

Orthodontists have observed that teeth movement occur at different rates, and that individuals show different responses to treatment. Some of these differences are depending on drugs and systemic factors that influence the bone remodeling **(Gameiro *et al*., 2007)**

The typical rate of orthodontic tooth movement depends on many factors including magnitude and duration of force, quality of bony trabeculae, patient age, number and shape of roots and type of tooth movement. Theoretically, the most efficient tooth movement is produced by application of light continuous forces. The heavy continuous forces need to be avoided, heavy intermittent forces can be clinically acceptable. The heavy forces can be physiologically acceptable only if the force level quickly drops to zero, so this provides a period of repair and regeneration before the next activation **(Proffit, 2012)**.

The amount and rate of tooth movement are entirely dependent upon the biological response to applied orthodontic forces.The rate of biological tooth movement with optimum mechanical force is about 1.0 to 1.5 mm in 4 to 5 weeks. **(Nanda and Kapila, 2010)**. The rate of tooth movement depends on the amount of bone turnover. Thus, the osteoclastic activity occurs at the site of periodontal ligament compression.

If the force exceeds the pressure (20–25 g/cm2 of root surface), tissue necrosis can occur due to the strangulated periodontium **(Asiry, 2018)**. mentioned that the teeth in maxillary arch are more responsive to orthodontics than those of the mandible because the maxilla is primarily composed of trabecular bone, which exhibits faster resorption than dense cortical bone **(Giannopoulou *et al.*, 2016)**. The rate of tooth movement is also affected by the type of movement as teeth move faster by tipping than by translation. Tipping of the teeth requires less resorption of bone adjacent to the middle of the root **(Graber, 2016)**.

A number of factors can slow down tooth movement, which includes age with teeth moving more rapidly in younger patients **(Dudic *et al,* 2013)** This is related to histologic factors, such as less dense alveolar bone and more cellular PDL in the children **(Schubert *et al.*, 2020)**. whilst drugs such as bisphosphonates (which reduce bone remodelling) and non-steroidal anti-inflammatory drugs (which suppress the inflammatory response) can both reduce the rate of tooth movement**(Cobourne, 2016) .**

1.2)The methods used to accelerate tooth movement in orthodontic treatment

The increased demand for rapid orthodontic treatment, especially by adult patients, has led to the development of different methods to accelerate the rate of tooth movement **(Alansari, 2017).** Theses include **:**

1.2.1) Non-surgical methods for the acceleration of OTM

These techniques have always been preferred by both the clinicians and the patients. All these approaches have shown acceptable outcomes with varying degrees of success **(Nuha *et al.*, 2021)** .

1.2.1.1) Biological approach :This includes chemical substances, neurotransmitters, and medications. Many of these factors have been involved in OTM acceleration research and the effect of their local and/or systemic administration has been tested, mainly in animal models, with variable results **(Nuha *et al.*, 2021).**

1) Systemic/Local Administration of Biological Substances and Hormones :

These factors work by stimulating the activity of osteoclasts either indirectly, by stimulating the expression of RANKL on osteoblasts, or directly by affecting osteoclast and osteoblast functions. However, these factors are rapidly flushed by blood circulation so daily systemic administration or daily injection is needed, necessitating several doses per day **(Saddi *et al.*, 2008).** These factors include:-

A) Epidermal Growth Factor (EGF)

Growth hormone (GH), also called somatotropin, is secreted by the anterior lobe of the pituitary gland. It has a stimulating effect on bone growth and remodeling, and a deficiency results in pituitary dwarfism. The action of GH is based directly on increases in the proliferation and differentiation of osteoblasts, as well as on induction of protein synthesis and mineralization **(Alicja and Adrian, 2018).**

It has been demonstrated that EGF has catabolic effects on bone. An organ culture study found that administrating a high dose of EGF to rats caused an elevation of osteoclahstic cell density on the trabecular bone surface and stimulated bone resorption **(kantarci, 2016)** . It found that the administration of exogenous EGF has an additive effect on the rate of osteoclast recruitment which product faster bone resorption and tooth movement **(Saddi *et al.*, 2008)** . Moreover, the regulatory role of EGF in fibrous tissue remodeling in the periodontal ligament (PDL) has also been demonstrated **(Kimura *et al.*,2013)**

B) **Parathyroid Hormone** :

Parathyroid hormone (PTH) is the major hormone regulating bone remodeling and calcium homeostasis. By increasing the concentration of calcium in the blood, it stimulates bone resorption **(kanatarci, 2016)** , is secreted by the parathyroid glands. .It consists of 84 amino acids, but the active fragment contains only amino acids 1 through 34q **(Theodosia, 2008)** .Although continuous elevation of PTH leads to bone loss, intermittent short elevations of the hormone level can be anabolic for bone .Experimental and clinical data has shown that daily administrations of PTH led to increases in bone mass, mineral density and strength. Goldie and King reported in their study that in the group fed with a calcium-deficient diet, parathyroid hormone secretion increased and resulted in a decrease in bone density, resulting in increased tooth movement speed and less root resorption **(Mehmet and Leyla, 2022).**

Some studies have shown that locally injected PTH induces local bone resorption, and it is more advantageous to give PTH locally rather than systemically . The development of a slow-release application that keeps the local concentration of PTH for a long time was very efficient. where the daily injection of PTH dissolved in gel medium allowed a slow release which caused 1.6-fold faster acceleration of teeth compared to daily injection of PTH dissolved in saline. solution which did not cause any acceleration **(Nimeri *et al.*, 2013)**

C) Prostaglandins

Prostaglandin are lipid autacoids synthesized by arachidonic acid by the action of cyclooxygenase (COX) **(Nuha et al.,2021)** . Prostaglandins, especially prostaglandin E2 (PGE2), are one of the most effective regulators of bone metabolism . Since prostaglandins play a role in both bone destruction and bone formation, researchers have conducted many studies on the role of prostaglandins during tooth movement **(Mehmet and Leyla, 2022)**.

Several animal experiments have shown that local application of PGE1, PGE2, or analogs of PGE1, PGE2, or thromboxane A2 increase the speed of orthodontic tooth movement. Local submucosal injection of PGE1 inhuman patients was also successful in accelerating tooth movement by 1.6-fold. Alternatively, orthodontic tooth movement is impaired by non-steroidal anti-inflammatory drugs, the compounds that inhibit the COX-1 and COX-2 enzymes that catalyze the rate limiting step of prostaglandin formation. One concern of using PGs clinically is the pain reaction from patients, since PGs are potent pain inducers. Another concern is increased root resorption concomitant with accelerated tooth movement, as indicated by several independent studies **(Huang *et al.*,2014) .**

D) Cytokines

Cytokines are soluble, small proteins that are produced by immune system cells, which modulate the cellular activity and play an important role in the bone remodeling processes in vivo **(Domingo et al., 2017).**

High concentration of cytokines such as interleukins IL-1, IL-2, IL-3 IL-6, IL-8, and tumor necrosis factor alpha (TNF) were found to play a major role in bone remodeling; moreover, interleukin-1 (IL-1) stimulates osteoclast function through its receptor on osteoclasts. It was also found that mechanical stress due to orthodontic treatment increased the production of prostaglandin PGE and IL-1 beta in the periodontal ligaments.The first experimental evidence was that after the application of a tipping force, Interleukin 1 was found in the periodontal tissues of cat canine teeth. RANKL, which is a membrane-bound protein on the osteoblasts, is a cytokine involved also in the acceleration of OTM that binds to the RANKL on the osteoclasts and causes osteoclastogenesis **(Sabane et al., 2016).**

E) 1,25-Dihydroxyvitamin D 3

Another agent that has been identified as an important factor in orthodontic tooth movement is 1,25-dihydroxycholecalciferol (1,25-DHCC) . This agent is a biologically active form of vitamin D and has a potent role in calcium homeostasis **(kantarci, 2016)** . sub-periosteal admistration of vitamin D enhances the activity and proliferation of osteoblast **(Alicja and Adrian, 2018).** In a few clinical trials, acceleration of orthodontic tooth movement was ademonstrated. After a daily oral dose of 0.25 μg of vitamin D, the mean difference in the retraction movement between the experimental group and the control group (who underwent orthodontic therapy without supplementation) was 1 mm/60 days **(Blanco *et al*., 2011).**

F) Thyroid hormones

The thyroid produces 2 hormones: thyroxine and Calcitonin. Thyroxine (T4) is a prohormone that can be converted to its active form tri-iodothyronine (T3) **(Theodosia *et al.*, 2008)** .Thyroxin administration lead to increased bone remodeling, increased bone resorptive activity and reduced bone density**(Kamatchi *et al.*, 2012).** This is probably due to the increased concentration of interleukin 1 (IL-1), which stimulates the formation of osteoclasts and the resorption process **(konopka, 2013)** .Despite the lack of clinical trials, the presence of metabolic diseases related to the thyroid gland should be taken into consideration when planning orthodontic treatment. In cases of hypothyroidism it is recommended to activate the device less frequently, whereas for patients with hyperthyroidism, a longer retention period is recommended**(Alicja and Adrain, 2017).**

Calcitonin inhibits bone resorption by direct action on osteoclasts, decreasing their ruffled surface which forms contact with resorptive pit. It also stimulates the activity of osteoblasts. Because of its physiological role, it is considered to inhibit the tooth movement; consequently, delay in orthodontic treatment can be expected**(kamtachi *et al.*, 2012).**

G)Relaxin

Relaxin is a naturally occurring hormone with a primary function of widening the pubic ligaments during childbirth and has many other functions such as collagen turnover, angiogenesis and anti-fibrosis effects. It is thought that relaxin might accelerate orthodontic tooth movement through inducing alterations in the PDL**(Nuha *et al.*,2021)** . It induces soft tissue remodelling instead of bone remodelling. When the quantity of collagen on the tension zone is increased, the rate of tooth movement increases. Relaxin's remodelling of PDL may lower the rate of recurrence after orthodontic therapy**(Hashimoto et al., 2001).**

H) Osteocalcin

Osteocalcin is a non-collagenous matrix protein that is abundant in bone tissue and functions as a negative regulator of mineral apposition and bone formation due to its high-binding strength with calcium and hydroxyapatite **(Tsao *et al.* , 2017)** . In studies in rats, it was demonstrated that local injections of purified rat OC accelerated the rate and increased the total amount of tooth movement . Histological examination revealed that this acceleration of tooth movement was caused by an enhanced recruitment of osteoclasts. No other side effects were reported, and no apparent macroscopic inflammation could be detected at the injection sites. Due to the restricted amount of existing data, no further conclusions can be currently formed regarding the effect of OC on the rate of tooth movement. **(kantarci, 2016).**

2) Neurotransmitters

The neurons originating from trigeminal ganglion supply dental and periodontal tissues. These neurons contain many neuropeptides such as substance P, Calcitonin gene-related peptide (CGRP) and vasoactive intestinal polypeptide (VIP); all these neurons are passive under neutral conditions. Mechanical force application during orthodontic treatment induces the release of active proteins, which in turn cause local inflammation and release of these neuropeptides **(asiry,2018) .** These neuropeptides can increase the vascular permeability and affect the bone remodeling directly **(sabane *et al*., 2016).**

1.2.1.2) Device-assisted treatment

This depends on the idea that applying orthodontic forces causes bone bending and a bioelectrical potential develops**(Nuha *et al*., 2021).** This approach includes:

A) Resonance vibration :

Resonance vibration Is based on a frequency equal to type natural frequency of an object, causing the largest amplitude of vibration of this object. **(Almpani and Kantarci, 2016)** When applied to the first molars in rats for 8 minutes once a week, resonance vibration (60 Hz) increased tooth movement by 15% compared with the controls, stimulating more expression of RANKL and osteoclast formation in the PDL **(Nishimura, 2008)**. Due to the natural frequency Of the vibration applied, there is no collateral damage to the periodontal tissues or root resorption of the treated teeth. Ultrasonic vibration is also a form of vibrational stimulation that is similar to resonance vibration. It has been reported that ultrasonic vibration accelerates tooth movement too **(kantarci, 2016)** . However, ultrasonic vibration of teeth might be associated with certain hazards, such as thermal damage to the dental pulp **(Trenter *et al*., 2003)** .Recently, a novel cyclical force device, 'Accele Dent', has been marketed, with claims that it may increase the rate of orthodontic movement. However, it provides vibration with only one fixed frequency (4 Hz), and there is still no peer-reviewed or long- term study on the biological or the clinical effects of the appliance **(kau, 2011)** .is based on delivery of high frequency vibration (30 Hz) to the teeth for approximately 20 minutes per day. The rationale is that this stimulates cell differentiation and maturation so that the bone remodeling necessary for tooth movement occurs more quickly **(Profitt , 2019).** On the pressure side, the concentration of the cytokine in the study group was on average more than 6 times higher than in the fluid collected from the control group **(Alicja and Adrian, 2018).**

Fig 1.4 : AcceleDent Aura **(Kau ,2011)**

B) Photomodulation or low level laser therapy (LLLT) :

low-energy laser irradiation has been utilized for several types of orthodontic applications, such as the reduction of post appliance adjustment pain or the treatment of traumatic ulcers in the oral mucosa **(kantarci , 2016).**

The advantages of this method are non-invasiveness, ease of use, and localized action **(Nuha *et al*., 2021).**

It has been stated that it stimulates the proliferation of osteoclasts, osteoblasts, and fibroblasts and thus accelerates tooth movement by affecting bone remodeling **(Nimeri *et al*., 2013)**. Low-dose laser application activates the cytochrome.C oxidase enzyme in electron transfer, causing an increase in adenosine triphosphate (ATP) in the cell, thus accelerating the tooth movement **(Eells *et al.*, 2004)** . It has been reported that low-dose laser application accelerates tooth movement through RANK-RANKL, M-CSF, and the receptor of this factor .In an animal study in which the effect of low-dose laser application on tooth movement speed was examined for the first time, 10 g orthodontic force was applied to the molar teeth of experimental animals for 12 days in three parts of the teeth (buccal, palatal, mesial) for a total of 9 minutes a day, 35.3 W/cm2 (54 Joule) Gallium aluminum arsenide (GaAlAr) diode laser with a wavelength of 830 nanometers (nm) was applied. As a result of histomorphometric and histological analyzes, it was reported that there was an increase in bone remodeling and a 1.3-fold acceleration in tooth movement with laser application **(Mehmet and Layela, 2021).**

C) Direct light electric current :

In animal studies investigating the effect of direct electric current on tooth movement, it has been reported that direct current is applied to the anode in the pressure regions and the cathode in the voltage regions, changing the bioelectric potential of the direct current and accelerating tooth movement. However, it has been reported that electrical current may have side effects such as ionic reactions causing damage to tissues and displacement of bone tissue with connective tissue **(Mehmet and Leyla, 2022)** . However, the use of this method is less popular than other methods as the existing evidence is insufficient to support whether electrical current could be effective in accelerating orthodontic tooth movement with safety in humans**.(Nuha *et al*., 2021) .**

D) Static or pulsed magnetic field :

Electromagnetic fields have a proven effect on cell membrane permeability. They can be divided into static magnetic fields (SMF) and pulsed electromagnetic Fields (PEMF) **(Alisaja and Adrian, 2018).**
Histological analyses have shown that magnetic fields influence and activate the alveolar bone remodeling. Hyalinization in the PDL was decreased in the presence of static magnetic field, which also contributed to accelerated tooth movement (shorten the lag phase) **(kantarci , 2016)**
.
Darendeliler et al. suggested that the static magnetic field accelerates tooth movement by shortening the pause period in which orthodontic tooth movement is not seen. It has been reported that the electromagnetic field affects the level of a group of enzymes responsible for the regulation of intracellular metabolism by

changing the sodium-calcium exchange rate in the cell membrane, thereby increasing cellular proliferation **(Farid, 2022)** .By affecting the cellular activity in the periodontal space, it accelerates both osteoclastic and osteoblastic activities, and thus, the movement takes place in a shorter time in force-applied teeth. It has been reported that due to the stabilization of the rate of resorption due to increased bone formation, mobility in the teeth decreases and pain is not observed in teeth exposed to chewing forces . In a study on the side effects of this method, it was reported that minor changes in blood chemistry may occur with a decrease in serum calcium level **(Mehmet and Layela, 2022).** However, another study showed that the magnetic Field increased root resorption of the treated teeth and increased width of the PDL, raising concerns about the effectiveness and safety of this method .**(Nuha *et al*., 2021).**

1.2.2) Surgical Methods for the Acceleration of the Orthodontic Tooth Movement:-

A number of methods have been proposed including surgical procedures to the interseptal bone to reduce the resistance to tooth movement . These procedures may reduce the bone density, and thus the resistance to tooth movement as well as increasing the body's inflammatory response (a process known as RAP or regional acceleratory phenomenon) **(Littlewood, 2019)**.

1.2.2.1) Corticotomy and osteotomy :

Corticotomy and osteotomy are surgical techniques that have been used clinically for many years. Osteotomy a is surgical cut in the bone, involving both the cortical and trabecular bones **(Lee *et al.*, 2008)**. Corticotomy, on the other hand, is a surgical cut through the cortical bone only, perforated or mechanically altered in a controlled surgical manner **(Almpani and kantarci , 2016)**. suggesting that this will reduce the resistance of the cortical bone and accelerate tooth movements **(Ghada *et al.*, 2013)** .

Wilcko *et al*. (2001) were first to suggest that tooth movement assisted with corticotomy may be due to a demineralization-remineralization process rather than bony block movement. This process resembled the regional acceleratory phe nomenon (RAP), a term initially used to describe rare cases of accelerated fracture healing . It is indeed an exaggerated response from that organism to an injured area to facilitate healing and has been associated with local increased bone turnover and decreased bone density.However, the RAP in the case of orthodontic tooth movement has also been attributed to the increased chemoattraction of macrophages. These macrophages remove the hyaline zone within 1 week after the application of orthodontic force . This early disappearance of the hyaline zone results in the acceleration of the tooth movement process around the corticotomy alveolar area. Thus, the RAP is influenced by both bone density and the degree of hyalinization of the periodontal ligament **(kantarci and Almpani, 2016)**.

The conventional corticotomy procedure involves elevation of full thickness mucoperiosteal flaps, bucally and/or lingually, followed by placing the corticotomy cuts using either micromotor under irrigation, or piezosurgical instruments (figures 1.4) .This can be followed by placement of a graft material, wherever required, to augment thickness of bone **(Shenava *et al.*, 2014)** .The surgical cuts are conducted by using micromotor under irrigation, or piezosurgical instruments **(Samantaray *et al.*, 2013)**.

The duration of the RAP usually lasts about 4–6 months in human bone, before it returns to a normal turnover rate **(kantarci and Almpani, 2016)** . Therefore, this phenomenon gives to the orthodontist a ‘window’ period of at least 4 months for accelerated movement **(Aboul-Ela *et al.*, 2011)** . During this period, corticotomy facilitated teeth moved on average twice faster than the control side. In a study that involved surgical holes technique for canine distalization, it was shown that the corticotomy-assisted canine distalization demonstrated 42.6% greater net canine distalization than the non-surgical side. **(Albustani and Abed, 2013)**. It has been reported that traditional vertical and horizontal osteotomies impose an increased risk of postoperative tooth devitalizaion or even bone necrosis, depending on the severity of injury to the trabecular bone. There is also an increased risk of periodontal damage, mainly in cases in which the interradicular space is less than 2 mm. **(Almpani and kantarci, 2016).**

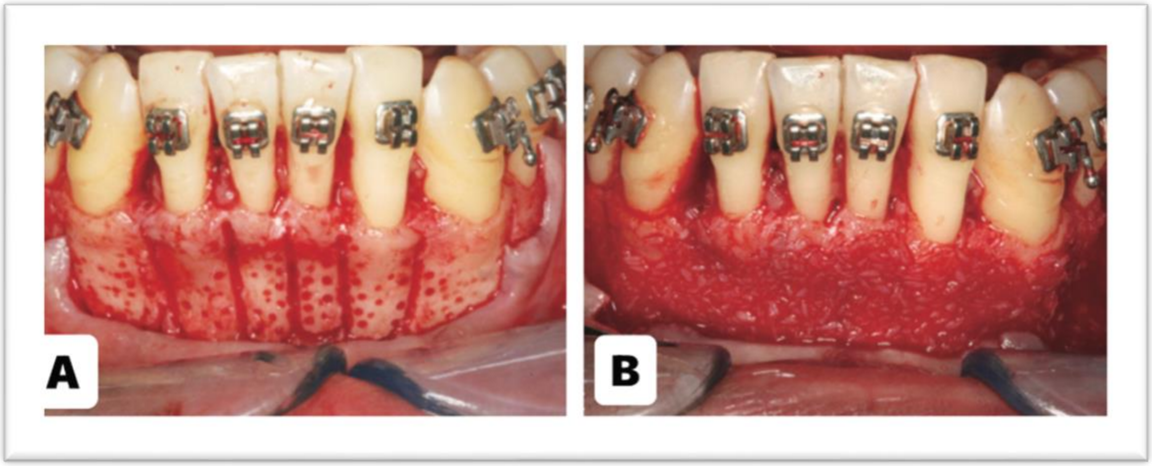

Fig 1.4 : Corticotomy preparation : A) Corticotomy and preparation of the bone over the lower incisor was done at the same time ; B) bone graft material was placed to reduce the chance of bone loss as the lower incisors were advanced.**(Proffit, 2019)**.

1.2.2.2) Piezocision :

Piezocision-aided orthodontics was developed to address the drawbacks of surgical corticotomy **(Hhuang *et al*., 2014)**. Like periodontally accelerated osteogenic orthodontics, it also speeds up tooth movement by alveolar corticotomy with less trauma, but instead of full-thickness flaps, small vertical cuts through the gingival tissues and periosteum are made to reach the bone cortex. Bone grafts are embedded in tunnels connecting the vertical cuts (figure 1.5). Vercellotti and Podesta,(2007) in their study, recommended the use of a piezosurgical blade in order to create safer and more precise corticotomies without causing osteonecrotic damage after flap removal in order to reduce surgical trauma and accelerate tooth movement .

In addition to direct bone injury by piezocision, vibration may also play a role in activating bone remodeling, since many modern commercial piezotomes incorporate high-frequency vibration. More studies are needed about the mechanisms of piezocision to accelerate tooth movement and to evaluate its effectiveness and long-term results.. Piezocision can be used as an adjunct to treat a number of malocclusions and aid in rapid orthodontic treatment in adults.Since it is much more minimally invasive than corticotomy, it is having high degree of patient acceptance, short surgical time and has less postoperative discomfort**(Dibart, 2015) .**

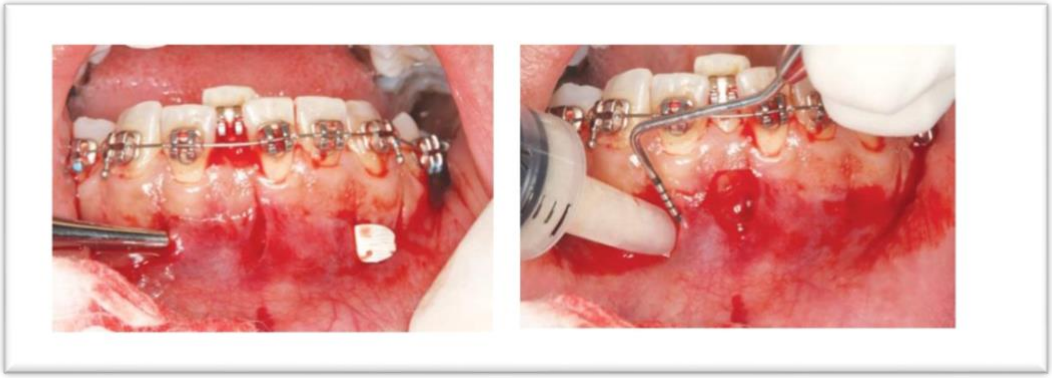

Fig 1.5 : Piezocision-aided orthodontics : A tunnel under the soft tissue is established, and the graft slurry is placed into the area with a syring to do bone grafting **(Dibart, 2009)**

1.2.2.3) Inter-septal alveolar surgery :

This surgical approach is called dis traction osteogenesis, which involves distraction of PDL or distraction of the dentoalveolar bone. For rapid canine retraction (after the extraction of the first premolar), the interseptal bone distal to the canine is undermined 1 to 1.5 mm in thickness and the socket is deepened to the length of the canine. The retraction of the canine is carried out by the activation of an intraoral device directly after the surgery. In this concept, the compact bone is replaced by the woven bone and tooth movement is easier and quicker due to the reduced resistance of the bone . It has been reported that this technique accelerates tooth movement without causing significant root resorption, ankylosis or root fracture. However, some results showed concerns regarding the vitality of the retracted canines after six months of retraction **(Leethanakul et al., 2014)** . It was found that these rapid movements are during the initial phases of tooth movement especially in the first week **(Ghada *et al*., 2013)**

Fiberotomy :

Fiberotomy is the surgical detachment of the marginal gingiva from the root surface and therefore separation of the mucoperiosteum from the alveolar bone. According to past and more recent studies in animals, fiberotomy alone may also accelerate orthodontic tooth movement to a certain degree**(Binderman *et al*., 2010)** This kind of incision seems to cause an abrupt drop of cellular strains of gingival fibroblasts , activating a chain of signals that propagate Osteoclastogenesis alveolar bone resorption on its periodontal ligament surfaces of the alveolar bone. Detachment of the mucoperiosteum from bone surfaces also yields a direct mild burst of local bone remodeling on its outer surfaces, which has been characterized as an RAP effect **(Wilcko, 2013 and Binderman *et al.*, 2010)** consequently , increased local bone turnover has as a result the acceleration of orthodontic tooth movement of the adjacent teeth. **(kantarci and Almpani, 2016).**

1.2.2.4) Surgery-first orthodontics :

Surgery-first orthodontics is a strategy to significantly shorten treatment duration for patients who need orthognathic surgery to correct a severe dentofacial deformity . **(Haung *et al*, 2014)** . Studies have shown that tooth movement after orthognathic surgery is much faster than with routine orthodontic treatment, which can be attributed to RAP stimulated by the surgical wound to the bone. **(Liou *et al.*, 2011).**

1.2.2.6)Micro-osteoperforations (MOP) .

The method of creating holes in the alveolar bone to increase osteoclastic activity in order to accelerate orthodontic tooth movement is called “alveosynthesis.” For this purpose, a disposable device called propel was designed by “propel orthodontics. The site of perforation is within the attached gingiva and close to the target teeth on the mesial and distal aspect of the roots of the teeth which will be moved **(Anand and Amrit, 2018)** . Clinically, the use of micro-osteoperforations significantly increases the expression of cytokines, which leads to a 60% shorter treatment time compared to a control group, and 2.3 times faster retraction of canines . **(Pobanz *et al*., 2013)** The procedure itself is described as effective, convenient, and less invasive than standard corticotomy. **(Alikhani *et al*., 2013).**

Fig1.6 : Micro-osteoperforations being done **(Sharma et al., 2019)**

1.3 Surgical versus non-surgical methods

The main difference between surgical and non-surgical orthodontic acceleration is the method by which they speed up the tooth movement process.Non-surgical orthodontic acceleration involves the use of devices or techniques to apply controlled pressure to the teeth, helping to speed up the tooth movement process.
Nonsurgical methods are the most preferable by the patient, being non- invasive but at the same time the needle injection is painful with discomfort to the patients and localized leakage of the drug . monitoring the systemic level is mandatory as long-term elevations can adversely affect other organs.The systemic application has long term side effects, also the application of some biological factors can increase the risk of root resorption and there's possible local or systemic side effects. **(kantarce and Almpani, 2016).** In addition, further research is needed to determine the safest dosage potency, dosage form suitable for administration, and proper frequency of administration **(Nuha *et al*., 2021)** .
Non-surgical approaches can be difficult to apply in everyday practice due to the use of expensive and specialized equipment and the need for regular and repeated administration of the intervention. **(Mohammad and Aslam, 2021)** . Also has been found their effectiveness has not yet been demonstrated, as is the case for chemical techniques**. (Carole and Mickel, 2021).**
The surgical approach provides the most favorable long term effect and can be utilized in a regular clinical setup without the need for general anesthesia. It's involves a surgical procedure to stimulate the bone surrounding the teeth, allowing them to move more quickly. This method is typically used in cases where
traditional orthodontic treatment may take too long, such as in adults with severe malocclusions. The surgical procedure involves making small cuts in the gums and bone, creating micro-fractures, which stimulate bone regeneration and allow the teeth to move faster. Nevertheless, the invasive nature of these techniques limited their popular use since any type of surgery, no matter how minor, is not free from

side effects **(Abed and Al-Bustani, 2013)** . the Disadvantages of the surgical methods include Surgical morbidity associated with the procedures, Increased cost of the procedure has to be borne by the patient , If not carried out properly chances of damage to the roots of adjacent teeth and Chances of pain, infection, and swelling after the procedure if proper hygiene is not maintained **(Sharma *et al*., 2019)**. Surgical intervention or corticotomy successfully used for rapid tooth motion without increasing the risk of root resorption and localized osteoporosis **(Abed and Al-Bustani, 2013)**. Although surgical techniques seem to have demonstrated their significant efficacy in accelerating orthodontic tooth movement, non-surgical techniques do not yet provide a sufficient level of evidence and / or safety to be performed in our routine clinical practice as orthodontists. **(Carole and Mickel, 2021).**

There is some evidence that low intensity laser therapy and corticotomy are effective, whereas the evidence is weak for interseptal bone reduction and very weak for photobiomodulation and pulsed electromagnetic fields**(Gkantidis *et al*., 2014)** .

According to the results of recently published systematic reviews and meta-analyses, the highest level of evidence for accelerating orthodontic dental movement procedures is for 'surgery-first' orthodontic cases, followed by corticotomy and low-level laser application. **(kantarci and Almpani, 2016).**

Abdelhameed and Refai and Rajasekaran and Nayak found that surgical interventions were more effective than the non-surgical ones in OTM **(Abdelhameed and Refai, 2018 and Nayak, 2014)** . On the contrary, Türker et al. found that the non-surgical intervention was more effective than the surgical one in the first month of upper canine retraction **(Türker et al., 2021)** . Moreover, Abdarazik et al., El Ashmawi et al., and Sedky et al. mentioned that there was no difference between the surgical and nonsurgical interventions regarding the acceleration of OTM **(Hajeer et al., 2022)** .

Overall, both surgical and non-surgical orthodontic acceleration methods have their own unique benefits and risks, and should only be used under the guidance of a trained orthodontist. Surgical acceleration is typically reserved for more severe cases, while non-surgical methods may be appropriate for less severe cases or for patients who prefer a less invasive approach.

Chapter two : Discussion

From the previous review about the nature of tooth movement, we can say that tooth movement rate can be determined by bone remodeling which is a result of inflammatory process in response to application of orthodontic forces. Increasing the applied force in order to accelerate orthodontic tooth movement is useless because this approach led to many problems including ankylosis, arrested tooth movement within the alveolar bone and root resorption rather than tooth motion acceleration. The addition of any procedure or the use of any devices to accelerate orthodontic treatment should be carefully considered and based on supporting scientific evidence and the desire of the patient. This made the researchers to investigate more approaches to reduce orthodontic treatment time by many methods. (Asiry, 2018 ; Kantarci et al,. 2016).Nonsurgical methods are the most preferable by the patient, being non- invasive; but at the same time the needle injection is painful with discomfort to the patient. The systemic application has long term side effects, also the application of some biological factors can increase the risk of root resorption and there's possible local or systemic side effects .Device-assisted treatment, most preferred by orthodontic patients and clinicians as it's the least invasive, non-painful approach, but more efficient application protocols and scientific evidence are necessary before their introduction to the clinical practice.

The surgical approach provides the most favorable long term effect Nevertheless, the invasive nature of these techniques limited their popular use since any type of surgery, no matter how minor, is not free from side effects in addition to the cost.
It has been found hat low intensity laser therapy and corticotomy are effective, whereas the evidence is weak for interseptal bone reduction and very weak for photobiomodulation and pulsed electromagnetic fields.
Abdelhameed and Refai and Rajasekaran and Nayak found that surgical interventions were more effective than the non-surgical while Türker et al. found that the non-surgical intervention was more effective than the surgical method.
In general Finally, more studies and investigations on human are mandatory to understand all aspects and nature of mechanisms behind the acceleration of OTM by either enhancing the effectiveness of existing methods or developing new techniques with a higher clinical efficiency, lowest side effect, more comfortable to the patient and cost-benefit.

Chapter Three : Conclusions And Suggestions

Conclusions:-

1- Finishing the orthodontic treatment successfully within a shortest period of time is still a relatively new horizon. Decisions on which method to be used depend largely on the orthodontist's preference, patient's acceptance and willingness; taking into consideration the cost, age and general health status of the patient.
2- The most recent and the least invasive methods like lasers, mechanical vibration, piezocision and microosteoperforations provide favorable results with a minimal side effect, unlike the aggressive surgical methods that accelerate tooth movement effectively but induce unfavorable effects locally or systemically.
3- In conclusion, the main difference between surgical and non-surgical orthodontic acceleration is the method used to speed up the tooth movement process. Surgical orthodontic acceleration involves a surgical procedure to stimulate bone regeneration, while non-surgical methods involve the use of devices or techniques to apply controlled pressure to the teeth.
4- Surgical acceleration is typically reserved for more severe cases, while non-surgical methods may be appropriate for less severe cases or for patients who prefer a less invasive approach.
5- Both methods have their own unique benefits and risks, and should only be used under the guidance of a trained orthodontist. Ultimately, the choice between surgical and non-surgical orthodontic acceleration will depend on the specific needs and preferences of the patient.

Suggestions

1- It is possible to study the effects of both surgical and non-surgical methods of tooth movement acceleration in more details.
2- To study the difference between surgical and non-surgical Approaches in more details

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