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Orthodontic Tooth Movement

A Project Submitted to
The College of Dentistry, University of Al-Mustaqbal, Department of Orthodontists Dentistry in Partial Fulfillment for the Bachelor of Dental Surgery

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Graduation Project Dedication

To the Creator of the soul and the pen, the Originator of the atom and the breath, the Creator of all things from nothingness, to the one who delivered the message and fulfilled the trust... and advised the nation...

To the Prophet of Mercy and the Light of the Worlds, to the pure masters and his firmest bond... the People of the House of Prophethood

To the desire of my heart and the closest to me than myself, hidden from sight but present in the eye of

insight, to the greatest remnant of God... the Master of the Age and Time (may God hasten his reappearance)

To the one who taught me that the world is a struggle... and its weapon is knowledge and understanding,To the one who withheld nothing from me, to the one who strove for my comfort and success, to the greatest and dearest man in the universe, my dear father

To that beloved one with the pure heart, to the one whom the Most Merciful commanded me to treat with kindness and benevolence, to the one who strove and suffered for my sake, to the one whose prayers were the secret of my success... my beloved mother, to... those with whom I share my moments... to those who rejoice in my success as if it were their own

With all my love, I dedicate this humble effort to you.

Acknowledgments

We thank God first and foremost for his countless love and support always, I pray that we will live up to be a responsible Doctor.
we would like to express my deep appreciation and indebtedness particularly to my supervisor Dr.Ahmed almusawey

For his endless support, kind efforts, time, advice and scientific opinions and I'm really proud to be one of his students.The completion of this project could not have been possible without the participation and assistance of so many people whose names may not all be enumerated. Their contributions are sincerely appreciated and gratefully acknowledged.

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LIST OF ABBREVIATION

Symbol	Abbreviation
LLLT	LOW-LEVEL LASER THERAPY
MT	MILLI- TESLA
MOPs	MICRO-OSTEOPERFORATIONS
OTM	ORTHODONTIC TOOTH MOVMENT
PEMF	PULSED ELECTRO MAGNETIC FIELD
PDL	PERIO DONTAL LIGAMENT
PTH	PARATHYROID HERMONE
RAP	REGIONAL ACCELERATORY PHENOMENON

Introduction

Orthodontics is a special discipline dedicated to the investigation and practice of moving teeth through the bone.Moving teeth through the dentoalveolar complex is a synergistic sequence of physical phenomenon and biological tissue remodeling. The physical behavior of tooth movement due to orthodontic force relies on Newton's Laws.

The tooth biological system reacts to variation in force magnitude, time of application and directionality through receptor cells and signaling cascades that ultimately produce bone remodeling and orthodontic tooth movement (OTM). focuses on the biology of tooth movement and its implication in clinical orthodontics **(Malik, Z et al.,2024)**

The modern therapeutic methods contributes prominently to theories of contemporary orthodontics . Among these, the concept of accelerated OTM is to achieve normal occlusion with shortening treatment period, and minimal side effects on the teeth and periodontal tissue . Various physical methods, such as low-level laser therapy (LLLT) , static magnetic field (SMF) , and pulsed electro magnetic field (PEMF) , are employed in OTM acceleration. Recent animal studies have shown that the SMF may possibly shorten the duration of orthodontic treatment **.(Sakata M,*et al.*2021)**

Similarly, histological studies have revealed that alveolar bone remodeling process is likely to be activated under the influence of magnetic fields, as the activity of osteoblasts increases new bone deposition on the tension side . Magnetic fields have the advantage of being able to cross both the mucous membrane and bone ; notably, they do not require patient cooperation . The recent development of small magnets made of new, powerful permanent magnetic alloys (neodymium-iron- boron) also known as rare earth magnets, has led to an increase in the

use of magnets . Such magnets are 20 times stronger than the magnets used previously; thus, they can be used at a size 20 times smaller than the previous ones with the same amount of resulting force. This feature made them suitable for the use inside the oral cavity easier and more comfortable for patients . The magnetic flux density was measured with a Tesla (T) or Milli-Tesla (mT) **.(Kuwajima Y,et al.,2019)**

However, few studies in the literature have examined the effect of static magnetic field (SMF) therapy on the rate of OTM in short-term animals . The SMF has been utilized in various randomized controlled clinical trials (RCTs) for orthodontic treatment, such as correction of Class II malocclusion correction of Class III malocclusion and closure of midline diastemas **.(Nimeri G.etal.,2019)**

On the other hand, many studies have suggested that a static magnetic field can enhance the effectiveness of anticancer drugs while minimizing cytotoxicity and side effects.Accordingly, the primary objective of this study was to investigate the effectiveness of a low-intensity static magnetic field (SMF) in accelerating upper canine retraction movement and reducing treatment duration. The secondary aim was to evaluate upper molar drift following canine retraction**.(Shenava S,et al.,2021)**

Aim of the study

1. To understand the biological mechanisms that cause teeth to shift in response to force, and to improve the rate, stability, and quality of this movement to achieve a better orthodontic outcome.
2. Research often focuses on how applied forces lead to bone resorption and formation, how to minimize negative effects like root resorption, and how to potentially accelerate the process to make treatment more efficient for adults.
3. The aim of the present study was to provide an overview and full details about the Orthodontic Tooth Movement .

Chapter one

Review of Literature

1.1.1 Biology of tooth movement

Orthodontic treatments are compared to being the most challenging process in dentistry because of the treatment time. For understanding the orthodontic treatments which is induced via tooth movement, it is necessary to study the process and the factors that result in delayed movement of the tooth. Typically, subjects undergoing orthodontic treatment are chosen based on specific criteria such as the nature of their malocclusion (misalignment of teeth), age, gender, and overall oral health. The specific methods of subject selection may vary depending on the study design and research objectives. Some of the trials were also performed on animals like rat, rabbits, and monkeys to gain the insight on biological processes. It helps to understand cellular and molecular events, bone remodeling processes, and tissue responses to orthodontic forces **.(Kacprzak A, and Strzecki A.2020)**

OTM is the result of a phenomenon of tissue remodeling process that is induced by forces that act externally on a biological system containing alveolar bone, PDL, tooth and gingiva . The tooth root is anchored to the alveolar bone socket through a fibrous connective tissue called as the perio dontal ligament (PDL). The forces provided by the orthodontic devices are transmitted and distributed to alveolar bone by periodontal tissues . OTM is also affected by the growth and development of specialized alveolar bone cells called osteoclasts and osteoblasts. These cells are in charge of the formation and resorption of bone . Together, these two cellular events support the remodeling of bone process and restore the bone matrix during adult life . Based on the theory of "pressure and tension," proposed it is generally accepted that bone remodeling is dependent on the hydrostatic pressure conditions equivalent to capillary pulse pressure. Osteogenesis, the formation of new bone, predominantly

occurs on the tension side of the PDL, whereas resorption, the removal of bone tissue, is primarily observed on the compression sides of the PDL **(Nimeri G,et al.,2022)**

In accordance with the "pressure and tension" theory, when forces are applied to a tooth, it leads to a state of tension on one side and compression on the other side. Prolonged compression experienced by the PDL results in resorption of alveolar bone, specifically on the pressure side. Osteoclasts play a crucial role in facilitating this resorption process, leading to bone loss. Simultaneously, new alveolar bone deposition occurs when the PDL fibers are exposed to tensile forces, stimulating bone formation by osteoblasts . Native paradental cells, leukocytes, and platelets release a milieu of inflammatory factors initiating functional units to remodel bone and paradental tissues; factors include cytokine IL-1β, IL-6, IL-10, Nitric Oxide (NO), Tissue necrosis factor-α (TNF-α), tissue growth factor β (TGF-β), macrophage colony-stimulating factor (M-CSF), Prostaglandins, OPG, and RANKL. Compression and tension zones are associated with specific mediators regulating resorption and deposition, respectively. Compression is associated with elevated Cycloxygenase-2 (COX-2) which catalyzes production of prostaglandins, including PGE2, from arachidonic acid. Prostaglandins act on osteoclasts, increasing intracellular cAMP concentrations and boosting their resorptive activity. PGE2 stimulates osteoblast differentiation and expression of RANKL and OPG. An increase in RANKL and M-CSF and a decrease in OPG release by osteoblasts collectively favors osteoclast differentiation and bone resorption **.(Shirude SS,et al.,2019)**

1.1.2 Center of Gravity:

The center of mass is called center of gravity in an environment where gravity is present. the center of gravity of the tooth is located more towards the crown of the tooth as the mass of the tooth is concentrated more coronally since the tooth is partially restrained as its root is embedded in bone its center of gravity moves apically and this is known as center of resistance in case of single rooted tooth center of resistance is on the long axis of tooth between the apical one third and the coronal tow third of the tooth. for a multirooted root, the center of resistance is probably between the roots 1-2 mm apical to furcation.(as in figure.1)

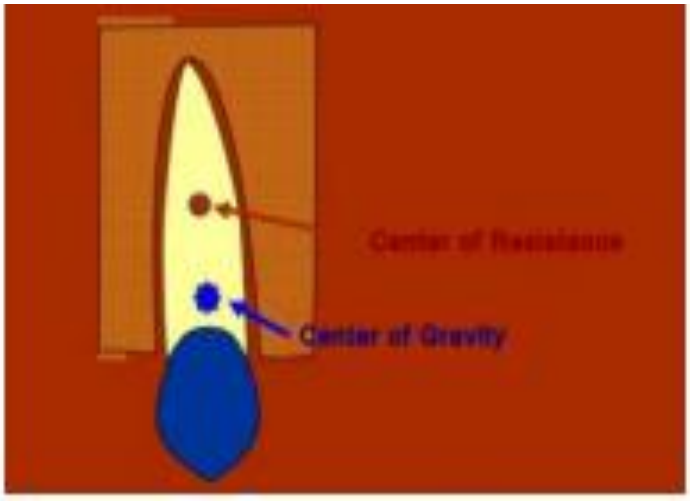


Figure.1 Center of Gravity

1.1.3 Moment of Force:

A measure of the turning tendency produced by a force. When a force is applied at any point other than through the center of resistance in addition of moving the center of resistance in direction of the force, a moment is created. In case of tooth, since it is embedded in the alveolar bone, we cannot apply force directly on center of resistance, but can apply force on the exposed part of the tooth, which is at a distance from the center of resistance. Therefore with a single force we invariably create a moment called as moment of force.

A Moment.

The direction of a moment can be determined by continuing the line of action of the force around the center of resistance.(as in figure.2) **(Doshi-Mehta G and Bhad-Patil.2020).**

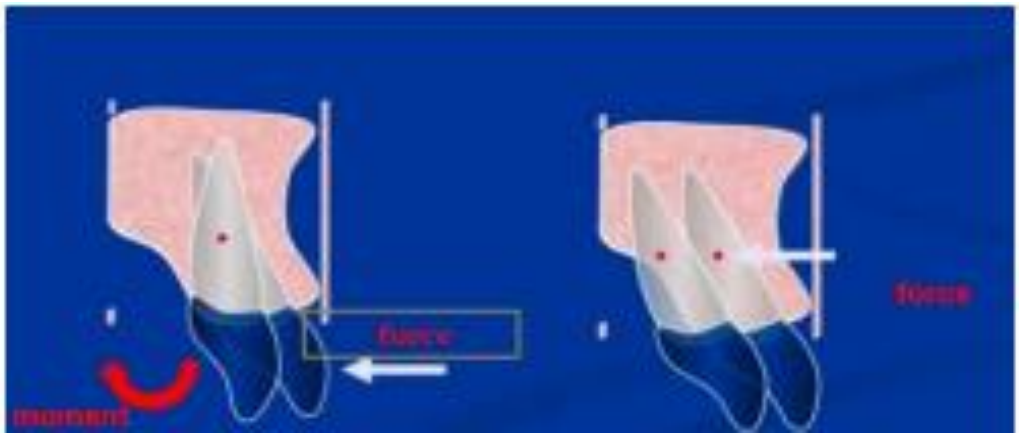


Figure.2 force around the center of resistance

1.1.4 Center of Rotation:

It may be defined as a point about which a body appears to have rotated as determined from its initial to final position The ratio of the counter-balancing moment to the force applied determines the type of tooth displacement, brought about by the combined application of a force and counter-balancing moment. As the counter-balancing moment increases, the center of rotation moves apically.(as in figure.3) **(Kantarci et al.,2016).**

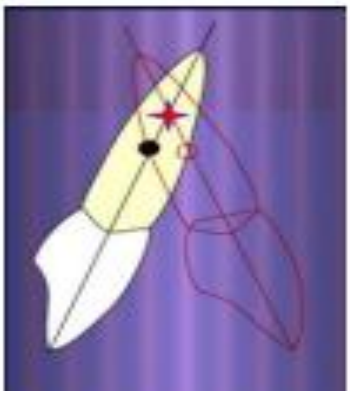


Figure.3 Center of Rotation

1.1.5 Couple:

Two equal and opposite, non – collinear forces are called a couple. Couple consists of two forces of equal magnitude, which are parallel to each other but not coincident and they face in opposite direction. Moment of couple . (as in figure.4) Is the force that tends to rotate the tooth in opposite direction than the moment of force and counterbalance it to achieve controlled tooth movements **(Almpani K and Kantarci.2019).**

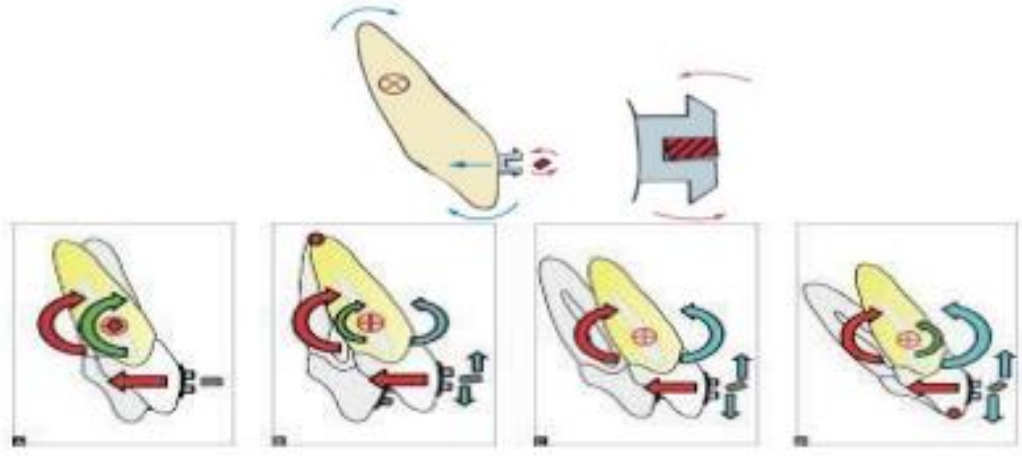


Figure.4 forces are called a couple

M/F (moment to force ratio) is the relationship between the force and the counter balancing couple that determines the type of tooth movement .

The main two types of tooth movements are:-

1.2 Types of Tooth Movement

1.2.1 Uncontrolled Tipping:-

The simplest tooth movement to carry out and is achieved by application of a force at one point on the crown of a tooth and the force is act upon a fulcrum which lies near the junction, between the apical one third and the coronal two- thirds of the root (the center of rotation close to the center of resistance) such that the crown moves in the direction of the

applied force and the apex in the opposite direction. With the tipping movements, areas of maximal pressure and tension are set up at their apical and cervical regions of the root. Movement is indicated when we want to change the inclination of the tooth and this tooth may be tipped mesially, distally, buccally or lingualy. This type of tooth movement can be performed by removable appliances. Force being applied by means of relatively simple springs acting directly upon the crown of the teeth being moved (like Z-spring, Recurved Z spring), also fixed appliance can perform it by application force upon a point contact to the crown of the tooth.(as in figure.5) **(Kantarci et al.,2016).**

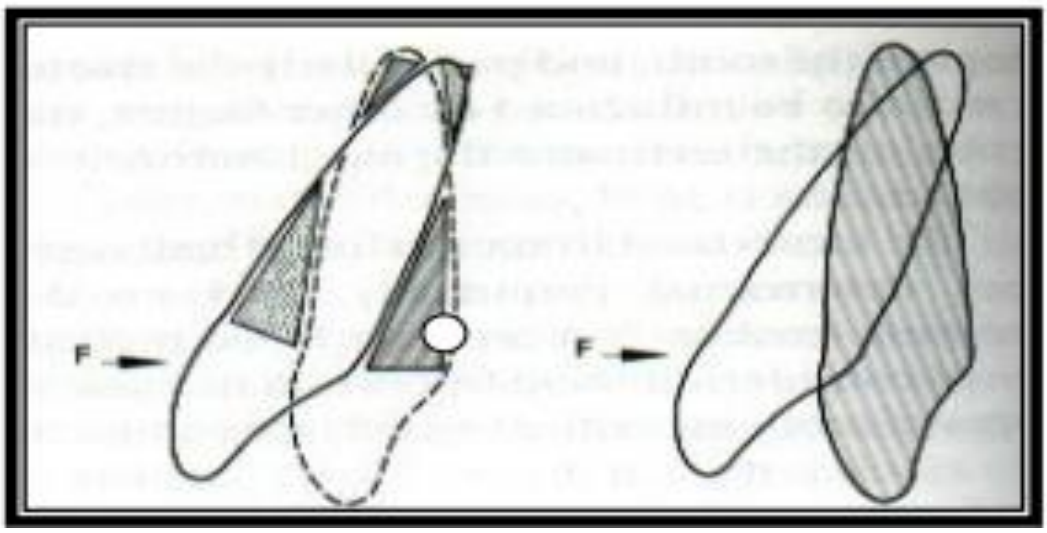


Figure.5 Uncontrolled Tipping of tooth

1.2.2 Controlled tipping:

In this case, the center of rotation lies close to the apex. Here the crown moves in one direction but the root position remains the same or gets minimally displaced. (as in figure.6)This is referred to as controlled tipping. This type of movement cant be achieved but removable appliance because it require moment of couple **(Alikhani et al.,2018).**

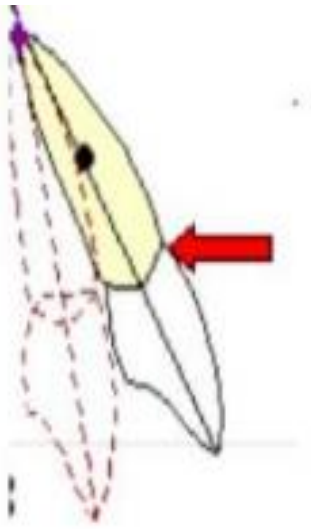


Figure.6 Controlled tipping

1.2.3 Translation or Bodily tooth movement:-

Bodily movement of teeth implies an equal movement of crown and root in thesame direction with no change or very little to their original inclination. It is not possible to move a tooth bodily by means of a force applied to the crown unless the tooth is prevented from tipping(moment of couple)With the bodily tooth movements the force is distributed reasonably evenly alongthe root axis. This type of force is not possible to be used with removable appliances **(Huang et al.,2019).**

1.2.4 Rotation:-

Is a movement "circular" of the crown and the root around their long axis in its socket and requires the application of a force couple. This can be produced either by applying a force to one point of the crown and a "stop" to prevent movement of other parts of the crown, or more efficiently by opposite forces to different areas of a tooth. .(as in figure.7)There is a much greater tendency for rotational movements to relapse. This appears to be due to the fact that although

the fibers which attach the tooth to the bone become reorganized fairly quickly during and after tooth movement, the fibers joining the tooth to the gingival tissue remain intact for along time, then becoming distorted during tooth movement. In rotational movements most of these gingival fibers are stretched, and this produces the tendency for relapse **(Bartzela et al.,2019).**

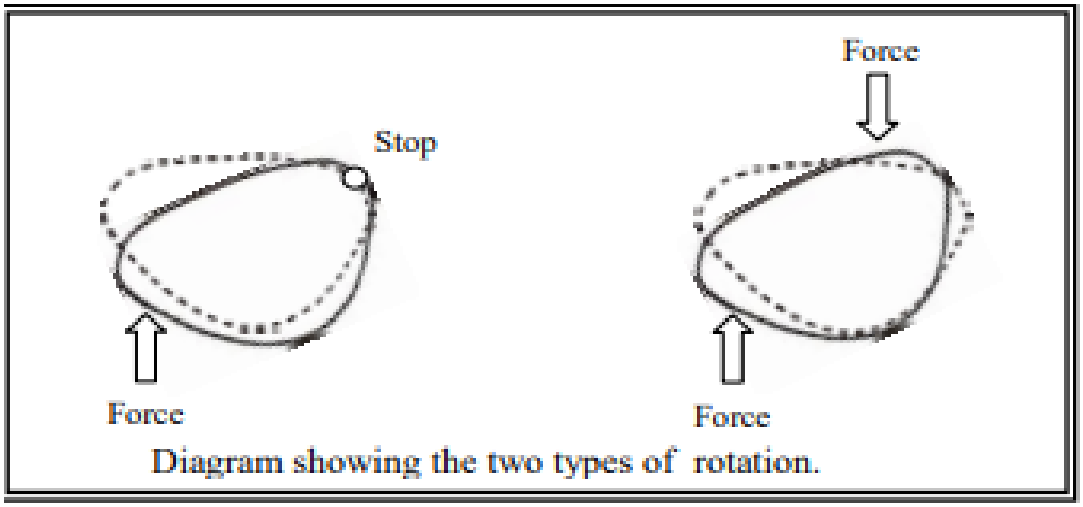


Figure.7 Diagram showing the types of rotation

1.2.5 Torque:-

Is a differential tooth movement of one part of a tooth (root), physically restraining any other part movement (crown) means it need moment of couple. It'scommonly applied to "Torque root" movement or "apical torque", which is the movement of the root of the tooth more than the crown of the tooth in a labio palatal direction in their own place. The center of rotation will be at occlusal third of the crown (as in figure.8) **(Doshi-Mehta G and Bhad-Patil.2020).**

Figure.8 Diagram showing the torque

1.3 Orthodontic Acceleration Techniques Three Major Categories:

1.3.1 Pharmacological Agents

Medications like prostaglandins, vitamin D, and other biochemical mediators may be injected or applied topically to stimulate osteoclast and osteoblast activity, thereby increasing the rate of bone resorption and formation around the moving teeth The use of specific growth factors or cytokines to directly modulate the cellular environment . Pharmacological methods may involve either local drug injections or systemic administration . However, their effects on post-retention relapse are variable, with some agents enhancing relapse risk. Studying these materials helps identify strategies that balance rapid tooth movement with long-term stability, improving both treatment efficiency and outcomes **(Nimeri G,et al.,2022).**

This study made a comparison between the acceleratory effect of corticosteroid, vitamin D (Vit D) and prostaglandin E2 (PGE2) regarding to the amount of orthodontic tooth movement and subsequent relapse occurred after finishing of orthodontic treatment and ensuing retention in rats. Animal models, such

as rats, are widely used in orthodontic research because they allow controlled investigation of bone remodeling and tooth movement, which is difficult to assess directly in humans . The null hypothesis of this trial was that no differences would exist among corticosteroid, vitamin D, and PGE2 in either the acceleration or relapse phases.

1.3.2 Physical Methods Used To Accelerate Tooth Movement In Orthodontic Treatment

Accelerating orthodontic treatment is a significant area of research in dentistry, as it can reduce the duration of treatment, improve patient comfort, and enhance outcomes. Several physical approaches have been explored to speed up tooth movement and optimize orthodontic processes. Below are some of the key physical methods **(Wang et al., 2023**).

1.3.2.1 Micro-Osteoperforations

MOPs involve creating small perforations in the alveolar bone around the teeth to induce a regional acceleratory phenomenon (RAP). This process increases bone remodeling and accelerates tooth movement. (as in figure.9)Minimally invasive, quick healing, and effective in reducing treatment time limitations: Requires precise placement and may cause temporary discomfort.

Figure.9 (Micro-Osteoperforations)

1.3.2.2 Low-Level Laser Therapy

LLLT uses low-intensity lasers to stimulate cellular activity, increase blood flow, and enhance bone remodeling. This can accelerate tooth movement by promoting osteoclast and osteoblast activity.(as in figure.10) advantages non-invasive, painless, and can reduce inflammation limitations: Requires multiple sessions and optimal dosing for effectiveness (**Andrade et al., 2023).**

Figure. 10 (Low-Level Laser Therapy)

1.3.2.3 Vibratory Devices

High-frequency vibratory devices apply gentle mechanical forces to the teeth and surrounding bone, stimulating cellular activity and accelerating tooth movement.(as in figure.11) Non-invasive, easy to use, and can be combined with traditional orthodontic appliances.Effectiveness varies among individuals, and long-term results are still under study **(Villasenor et al., 2020).**

Figure.11 Vibratory Devices

1.3.2.4 Photobiomodulation

PBM uses light therapy to stimulate cellular activity and reduce inflammation, promoting faster tooth movement (as in figure12).Non-invasive and easy to apply.Limitations requires multiple sessions and optimal wavelength/dosage for effectiveness **(Malik, Z., Singh, et al .2024).**

Figure.12 Photo biomodulation

1.3.3 Surgical Methods for the Acceleration of the Orthodontic Tooth Movement

1.3.3.1 Alveolar Osteotomy-Assisted Tooth Movement

Osteotomy is defined as a surgical cut through both the cortical and trabecular bones. This term is frequently used when describing the creation of bone segments. In orthodontics, osteotomies have been used to enhance and accelerate tooth movement. Cunningham presented 'Luxation, or the immediate method in the treatment of irregular used mesial and distal interseptal osteotomies to reposition palatally inclined maxillary teeth and stabilized them in correct occlusion with wire ligatures or metal splints **(Merrill and Pedersen.2022).**

The most important feature was the fact that this combined active surgical-orthodontic treatment reduced the procedure time to one third that of conventional treatment and allowed more predictable treatment in older patients introduced his 'bony block' technique, a surgical procedure involving both osteotomy and corticotomy to accelerate orthodontic tooth movement, based on the concept that teeth move faster when the resistance exerted by the surrounding cortical bone is reduced via a surgical procedure. Kole's procedure (as in figure.13)involves the reflection of full thickness flaps to expose buccal and lingual alveolar bone, followed by interdental cuts through the cortical bone, barely penetrating the medullary bone **(Amit.2022).**

Figure.13 Kole's procedure

1.3.3.2 Alveolar Corticotomy-Assisted

Corticotomy involves surgically altering the cortical bone to reduce resistance and enhance tooth movement. This is often combined with bone grafting (periodontally accelerated osteogenic orthodontics, or PAOO) (as in figure.14)Significantly reduces treatment time and improves bone support. Limitations invasive, requires surgical intervention, and has a longer healing timing **(Lee et al., 2023).**

The invasiveness of the corticotomy procedures requiring full mucoperiosteal flaps constituted a serious drawback for their widespread acceptance among orthodontists and patients. Therefore, more conservative flapless corticotomy-restricted techniques have recently been proposed. These procedures can be completed more quickly and might be preferable if patient discomfort is

indeed minimized and if treatment efficiency is maintained.

Figure.14 Corticotomy-Assisted Orthodontics

1.3.3.3 Piezocision

Combines micro-incisions in the gingiva with piezoelectric bone cutting to stimulate bone remodeling and reduce resistance to tooth movement.(as in figure.15) Minimally invasive, precise, and reduces treatment time significantly requires surgical expertise and may involve minor post-operative discomfort **(Patel et al., 2022).**

Figure.15 bone cutting by Piezocision

1.3.3.4 Distraction Ontogenesis

A method for generating new bone by progressively distracting healing surfaces, following the complete osteotomy of a bone. Essentially it is a bone-modeling procedure that produces perivascular woven bone, which then condenses and remodels to mature lamellar bone It is suggested that formation of new bone with a width of approximately 1 mm/day can be achieved by this method **(Guerrero.2019).**

Distraction ontogenesis was performed in the human mandible were the first to apply this concept to orthodontic tooth movement in order to perform rapid canine retraction through distraction osteogenesis of the periodontal ligament. They considered the periodontal ligament as a 'suture' between alveolar bone and tooth and investigated the accelerated orthodontic tooth movement into newly distracted bone after mandibular distraction osteogenesis in a canine model in humans. Their results showed that rapid orthodontic tooth movement can be achieved with this technique. No evidence of complications

such as root fracture, root resorption, ankylosis or serious soft tissue dehiscence was reported at the end of dentoalveolar distraction, at least in the short term. However, a number of other complications have been associated with the distraction osteogenesis techniques, such as increase in gingival sulcus depth , anchorage loss, tipping of the anchorage and retracted teeth and, more frequently, loss of pulpal vitality **(Liou and Huang .2020).**

1.4 Considerations for Clinical Application

Patient-Specific Factor Age, bone density, and medical history can influence the effectiveness of these methods. Each method has potential risks, such as infection, discomfort, or root resorption, which must be weighed against the benefits multi disciplinary approach combining physical methods with biological or surgical approaches may yield better results **(Nimeri G,et al.,2022).**

1.5 Technological in orthodontic Tooth Movement

1.5.1 Self-Ligating Brackets

These brackets use a built-in clip to hold the arch wire, reducing friction compared to traditional brackets that use elastics. This can lead to faster treatment times, shorter appointments, and a more comfortable experience.(as in figure.16) Self- ligating braces are becoming a popular choice for people looking to straighten their teeth without the extra hassle. Unlike traditional braces, they don't use elastic bands to hold the wire in place. This small change greatly affects how they feel, how often need adjustments, and even how long treatment might take **(Harradine N.2018)**

Figure.16 Self-Ligating Brackets

1.5.2 Aligner Systems

Modern aligner systems, such as improved Invisalign,(as in figure.17) use optimized attachments that are more accurately placed to guide tooth movement. Enhanced control over tooth movement and more predictable outcomes, especially for complex cases.

Invisalign has developed advanced technology and materials to expand the application of clear aligner therapy beyond simple cases. The Invisalign

system is a virtually invisible treatment that uses an innovative approach to gently yet effectively straighten the crooked teeth moves the teeth to the desired position through a series of custom-made removable aligners made with unique Smart Force technology a brand of clear aligners manufactured by Align Technology and has been used to treat more than 9 million patients **(Weir T. 2017).**

Figure.17 Invisalign

1.5.3 Temporary Anchorage Devices (TADs)

Small devices are temporarily placed in the bone to provide a stable point of an chorage.They are used in conjunction with braces or aligners to control difficult tooth movements that are otherwise hard to manage, shortening treatment time and improving outcomes. enhance the efficiency of clear aligner treatments. They allow for controlled and targeted tooth movements for complex cases.

Incorporating TADs in clear aligner treatments can allow for stubborn tooth movements that might otherwise require extended treatment times or invasive procedures. With CAT, there are numerous ways to attach elastics from TADs to the aligner (as in figure.18) **(Tikku T, et al.,2020).**

These include hooking the elastic from the mini screw to a precision cut made on the aligner itself, attaching the elastic to a button bonded to the tooth surface with a cut-out made on the aligner to accommodate it or simply connecting the elastic to another minis crew, allowing it to pass over the aligner the advantages Ease of insertion and removal can be inserted in many anatomical site immediate loading small size and low cost

Figure.18 Temporary Anchorage Devices (TADs)

1.5.4 3D Printing and Customized Appliances

3D printing allows for the creation of highly customized appliances, such as brackets and aligners, that are tailored to the patient's specific dental anatomy. Improved fit, comfort, and biomechanical performance. It also allows for the direct printing of aligners with customized features, leading to more precise force delivery **(Bai, Y.X.2022).**

1.6 Risks of treatments tooth movement

Some of these effects are not fully understood, such as root resorption, and others are associated with orthodontic treatment without supporting evidence. Consideration of risk factors prior to treatment is important. Only risk factors that have been supported by previous evidence will be reviewed in this article. These adverse effects include root resorption, pain, pulpal changes, periodontal disease, decalcification, and temporomandibular dysfunction (TMD).

1.6.1 Biological risks

a.Root resorption

The progressive destruction of a tooth's root, caused by orthodontic mechanics, trauma, or other factors, can lead to tooth shortening and, in severe cases, tooth loss. . If the patient develops additional pathosis, such as periodontal disease, this may further compromise the support of the tooth and the patient can eventually loose that tooth.

However, no reports in the literature have documented tooth loss caused by root resorption. A long-term case report documented a follow-up of a case of severe root resorption that occurred for 33 years, and the affected teeth were found to be functional **(Al-Qawasmi RA, Hartsfield JK, Jr., et al.2023).**

b.Periodontal damage

Gingivitis, alveolar bone loss (periodontitis), and loss of attached gingival support .The periodontal reaction toward orthodontic appliances depends on multiple factors, such as host resistance, the presence of systemic conditions, and the amount and composition of dental plaque. Lifestyle factors, including smoking, can also compromise periodontal support **(Brägger and Lang, 2019).**

Additionally, the negative effects of uncontrolled diabetes on periodontal support are well established . Orthodontic treatment in uncontrolled diabetic individuals is contra indicated.including flap sloughing, loss of alveolar crest, or swelling, particularly after surgical procedures **(Safkan-Seppala and Ainamo.2020)**

1.6.2 Patient compliance issues

a.Difficulty following instructions:

Patients may have difficulty maintaining proper oral hygiene or following other specific instructions required for treatment success. Patients may lack the motivation for the long-term commitment required for some treatments, leading to a failure to achieve ideal results.

Patients are asked to follow an oral self-care regimen, they are being given a target or goal (for example, brush twice a day) and their task is to control or regulate their behavior to achieve that objective. Unfortunately, patients often fail to meet the expectations set forth by the clinical recommendation.

The problem of poor patient compliance with oral hygiene regimens by applying the general principles that govern the self-regulation of behavior. The component parts of a behavioral self-regulation model are reviewed in the context of oral self-care. Research in the area of toothbrushing behavior is reviewed and methods for providing patients with feedback about their degree of compliance are discussed **(Ismail AI,et al.,2021).**

Chapter Two

Discussion

The auxiliary wire carrying the magnet was covered with flexible vacuum-formed sheets 0.5 mm in thickness to secure a smooth surface with soft tissues for the patient's ultimate comfort and to protect the magnets from corrosion and saliva.The speed of upper canine retraction and anterior-posterior molar movement, on both the control and experimental sides were evaluated using a digital scanner to perform measurements via a computer program (Exocad - Dental CAD 3.1 Rijeka). The accuracy and reliability of this method were proven previously in the literature **.(Ishida Y,et al.2020)**

The results of Tengku showed that the speed of upper canine retraction on the experimental side was significantly greater than that on the control side during the first and second months and during the overall duration of retraction (P value < 0.05). The null hypothesis (H0), which stated that the SMF does not accelerate upper canine retraction, was rejected. These findings are in agreement with the findings who reported similarly that the SMF is effective at accelerating upper canine retraction. However, there the difference in the rate of acceleration might be due to the different magnets used, which affects the intensity of the magnetic field**(Tengku BS,et al.,2020).**

Always, the majority of orthodontic patients are demanding for a safer and shorter orthodontic treatment duration, especially when con sidering adult orthodontics. Success achieved from foremost trials encouraged the development of various surgical and non-surgical tech niques, with emphasis to minimize the adverse effects. The rate of OTM is determined by bone remodeling, which is a result of inflammatory processes in response to application of orthodon tic forces. Increasing the applied force in order to accelerate OTM is proven useless because this approach led to many adverse

effects including ankylosis, arrested tooth movement within the alveolar bone and root resorption rather than tooth motion acceleration. Alternatively, research was directed towards introducing local mediators or injuries to the alveolar bone in an attempt to reduce orthodontic treatment time. The systemic administration of medicines/chemical substances carries the risk of systemic side effects. Being less invasive, non-surgical methods represent the most prefer able approach by the patients; yet methods requiring local injections impose discomfort to the patients due to the painful needle injection. Local administration of vitamins and hormones, e.g. calcitriol and para thyroid hormone, is effective in accelerating tooth motion; however, monitoring the systemic level is mandatory as long-term elevations can adversely affect other organs**(Taddei SR,et al.,2022).**

In addition, further research is needed to determine the safest dosage potency, dosage form suitable for adminis tration, and proper frequency of administration. In spite of attempting a wide variety of device-assisted treatments, evidence is insufficient so far to justify their popular use in the daily based clinical practice. A novel cyclical force device premised on ultrasonic vibration, named Accele Dent, has been studied with claims that it may increase the rate of OTM. This device delivers a high-frequency vibration (30 Hz) to the teeth for approximately 20 minutes per day to enhance tooth motion, yet the reduction in treatment time was non-significant without evidence about the long-term biological or clinical effects of the device **(Kuwajima Y,et al.,2019).**

Discussion

The present survey was conducted to assess clinicians' perspectives on orthodontic tooth movement, including factors influencing treatment decisions and appliance usage. Data were collected electronically using Google Forms, targeting a sample of dental practitioners, including orthodontists and general dentists. A total of 25 participants responded to the survey. Responses were systematically recorded and analyzed using Google Sheets, facilitating structured data interpretation and summary statistics.

Analysis revealed that a significant proportion of clinicians consistently monitor and adjust orthodontic tooth movement based on clinical indications. More experienced practitioners demonstrated greater confidence in decision making regarding appliance selection and treatment sequencing, suggesting that clinical experience significantly affects treatment strategies. The survey also highlighted that patient cooperation and compliance remain critical factors affecting the efficiency and outcomes of orthodontic interventions.

Furthermore, the survey responses indicated variability in the use of different orthodontic appliances, reflecting differences in clinical preference, case complexity, and familiarity with emerging technologies. While modern methods, such as self-ligating systems and skeletal anchorage devices, are increasingly incorporated, traditional approaches continue to hold clinical relevance, particularly in straightforward cases or where patient compliance is predictable.

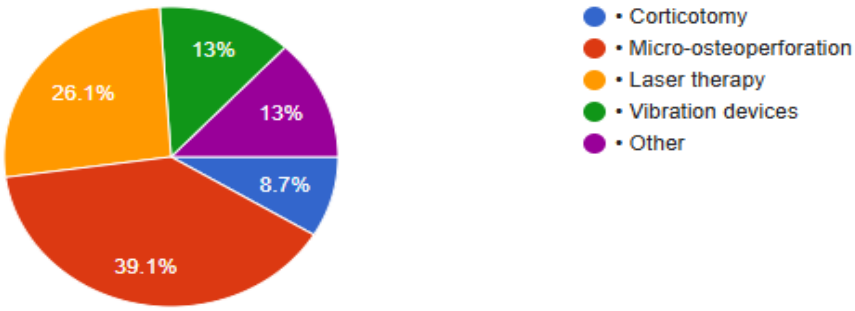
Despite the valuable insights provided, this study has several limitations. The relatively small sample size (n = 25) limits the generalizability of the findings. Additionally, the use of a self-administered questionnaire introduces potential response bias, as data are based on clinicians' self-reported

practices rather than direct observation. Finally, the survey was limited to a specific population, which may not fully represent broader clinical settings.

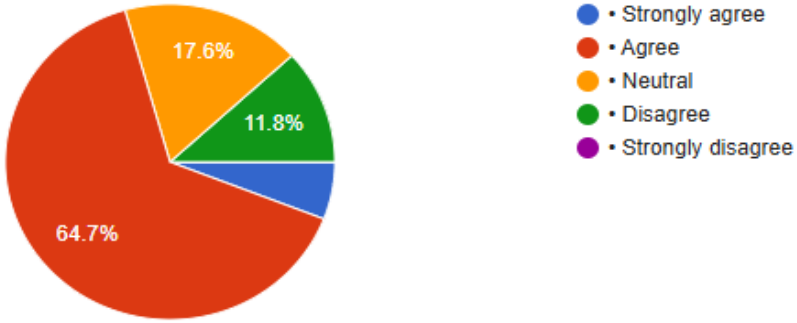
Overall, the results underscore the importance of integrating clinical experience, patient factors, and evidence-based practices when managing orthodontic tooth movement. The findings suggest that while modern orthodontic technologies enhance treatment possibilities, traditional principles and careful monitoring remain essential to achieving optimal outcomes.

Questionnaire Survey

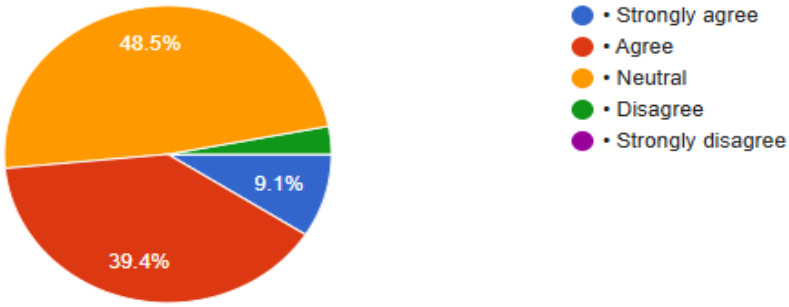
7. (If Yes) Which method do you use most frequently?



9. Acceleration techniques effectively reduce treatment time



10. These methods are safe for patients



Chapter Three

3.1 Conclusion

1. Physical approaches for accelerating orthodontic treatment offer promising ways to reduce treatment time and improve outcomes.

2. The most recent and the least invasive methods like lasers, mechanical vibration, piezocision and microosteo perforations provide favorable results with a minimal side effect, unlike the aggressive surgical methods that

3.Low-intensity direct electrical current could be an effective method to accelerate orthodontic movement.

4.Self-ligation does not truly accelerate biologic tooth movement, but it improves efficiency in alignment and reduces chair time.

• Superelastic wires + accurate bracket positioning + TADs + digital planning can significantly shorten treatment overall.

• True biologic acceleration comes only from RAP-based surgical methods or photo biomodulation

5.Best clinical evidence: Surgical methods, especially corticotomy-based techniques.

• Most practical non-surgical option: LLLT / photo biomodulation.

• Least reliable: Vibration devices (mixed evidence).

• Not routinely used clinically: Pharmacological & gene therapy

3.2 Suggestions

1.Randomized controlled studies are required to compare between different methods and identify the best techniques to shorten orthodontic treatment time.

2. Future study suggested about long term effects of any type of physical factors on the periodontium

3. Future research should prioritize translational studies, minimally invasive innovations, and interdisciplinary approaches to optimize physical acceleration methods

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