UNIVERSIDADE FERNANDO PESSOA

DISPOSITIVOS DE ACELERAÇÃO DE MOVIMENTO ORTODÔNTICO DURANTE TRATAMENTO ORTODÔNTICO COMBINADOS COM ALINHADORES, PERSPETIVA PROFISSIONAL: UM ESTUDO PILOTO

[Orthodontic movement acceleration devices during orthodontic treatment combined with aligners, professional perspective: a pilot study]

Dissertação de Mestrado

Mestrado em Medicina Dentária

Dominique Melanie Tijssen

Orientador:

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RESUMO

Objetivos: O objetivo principal do presente estudo é analisar os interesses atuais dos ortodontistas em técnicas de aceleração do tratamento ortodôntico, com foco na vibração de alta frequência e na sua aplicação clínica.

Materiais e Métodos: O presente estudo foi aprovado pela Comissão de Ética da Universidade Fernando Pessoa. Foi enviado um inquérito online anónimo a um grupo de médicos dentistas_da Europa, América do Sul e América do Norte para analisar o conhecimento dos mesmos acerca da combinação do tratamento com técnicas auxiliares, tais como o uso de vibração de alta frequência, para acelerar o movimento dentário ortodôntico, diminuído o tempo de tratamento ortodôntico e melhorar a experiência do paciente durante o tratamento ortodôntico.

Resultados: A amostra total de questionários respondidos foi constituída por 80 sujeitos que responderam ao questionário de forma voluntária e anónima. A maioria dos participantes (30%) era de Espanha, 21,25% do Brasil, 16% dos Estados Unidos, 10% do Equador, entre outros locais de menor dimensão. Dos participantes que têm conhecimento sobre os dispositivos de vibração de alta Frequência, o que corresponde a 48,75% do total de participantes, apenas 54,6% têm experiência com estes dispositivos no tratamento dos seus pacientes. E desses 54,6%, a maioria continuaria a usar aparelhos de alta frequência em combinação com a ortodontia para diminuir o tempo de tratamento.

Conclusões: A utilização da vibração de alta frequência como ferramenta na prática ortodôntica merece uma análise mais completa e abrangente para facilitar a sua utilização nos planos de tratamento diários propostos pelos ortodontistas. Isto é particularmente importante na Europa, onde se observou um conhecimento relativamente menor entre os participantes relativamente à existência e às potenciais aplicações dos dispositivos vibratórios de alta frequência.

Palavras chave: Vibração de alta frequência, ortodontia, acelerador de movimento.

ABSTRACT

Objectives: The primary objective of the following study is to analyze the current interests orthodontists may have in treatment acceleration techniques, focusing on high-frequency vibration and its clinical application. We will discuss the potential clinical applications during an orthodontic treatment as well as examine the challenges and future prospects of implementing this innovative approach in orthodontic practice.

Materials and Methods: The present study received approval form the ethics comity of Universidad Fernando Pessoa. An anonymous online survey was sent to a group of orthodontists practicing in Europe, South America as well as North America in reference to the knowledge on combining treatment with aiding techniques such as, the use of high frequency vibration in order to accelerate treatment duration times and enhance the patients experience while undergoing an orthodontic treatment.

Results: The total sample of questionnaires answered consisted of 80 subjects whom answered the questionnaire voluntarily and anonymously. The majority of participants 30% were from Spain, 21.25% from Brazil, 16% from the United States, 10% from Ecuador among other smaller sample places. Out of the participants that have knowledge over HFV devices which is a notable 48.75% of the total participants as seen in graph 2, only 54.6 % have used HFV devices with their patients (graph 4). And out of that 54.6% the majority would keep in using HFV devices in combination with orthodontics to diminish the treatment time.

Conclusions: The utilization of high-frequency vibration as a tool in orthodontic practice warrants a more thorough and comprehensive examination to facilitate its use into the daily treatment plans proposed by orthodontists. This is particularly important in Europe, where a relatively lower awareness among participants was observed regarding the existence and potential applications of high-frequency vibrational devices. This process of deeper exploration is essential for ensuring that practitioners can balance out the advantages offered by high-frequency vibrational devices to optimize patient care.

Keywords: Orthodontics, High frequency vibration, Acceleration techniques.

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ABREVIATION INDEX

High frequency vibration – HFV

Intraoral medicine – IO

Newtons – N

Low-magnitude– LM

1. INTRODUCTION

How can orthodontic treatment duration time be shortened and the treatment become more efficient? Are orthodontist really interested in addressing this ongoing topic? Orthodontists devote their time to create functional and harmonious occlusions for their patients, which most usually also have to meet high esthetic requirements. Year after year this process has become more and more predictable with the implementation of new appliances and techniques, although, it seems that there is still the need to reduce treatment time as well as discomfort perceived by the patients. Duration of orthodontic treatments is one of the biggest challenges that orthodontists face; time in combination with perceived pain and esthetics have become decisive factors regarding the acceptance rate when proposing an orthodontic treatment (Moresca, 2018; Pachêco-Pereira et al., 2015). Leading patients to choose more invasive treatments, in the pursue of obtaining quicker results which tend to compromise other aspects such as tooth integrity and vitality with irreversible consequences.

Now a days there is a tendency for people to want a quick and easy solution to obtain satisfactory results overall and that does not exclude their oral health specially regarding oral esthetics. Not to mention the implications of having force applied directly to the teeth for a long period of time which can lead to root resorption as well as poor oral hygiene meaning that long treatments can also be counterintuitive (Mayama et al., 2022). These are the main reasons clinicians are always in the search for new techniques to better tend to biological and personal requests. There has not been a consensus among orthodontists about treatment duration time but according to some studies there is a wide range of time estimates going from 14 to 33 months of treatment with a mean value of 24.6 months of treatment time (Moresca, 2018; Tsichlaki et al., 2016). The speed at which teeth move is a crucial factor which significantly influences the overall duration of orthodontic treatment (Pavlin et al., 2015).

A wide variety of therapies and approaches have been explored throughout the years with the objective to accelerate tooth movement, some of these being a lot more invasive than others and some being more costly than others (Uribe, et al. 2014). These therapies range from surgery (cortictomies and or osteotomies), laser therapy, intraoral medicine, to high-frequency vibration appliances. In the present questionnaire-based study, we shall focus on the ladder technique, high-frequency vibration (HFV). This is a new and interesting

tool orthodontists can use to their advantage given its lack of secondary effects, the skills required for its application, which are not very demanding, as well as price point. That compared to other proposed techniques which aim to stimulate bone remodeling and resulting in the repositioning of teeth by using biological response of bone to mechanical stimuli at a faster rate (Katchooi et al., 2018; Uribe et al., 2014).

The history of vibration and medicine has a long trajectory. The interest of using vibration to help patients better deal with a wide variety of health struggles was sparked in the 1800, when doctor Charcot had observed that after long rides in carriages, trains, or horses patients with Parkinson's disease experienced great amelioration of some of their symptoms. Inspired by this observation he later developed a vibration replication device to provide rhythmic movement (Mariotti, 1957). Further on in the 20th century Vladimir Nazarov started to apply this knowledge to treat the members of the Russian Olympic team in order to speed their physical recovery after intense training or matches. Later on it was also used by the Russian astronauts to counter act bone loss seen following the return from outer space missions, this has inspired many scientists in the medical filed to create and explore different vibration devices that might alter the way the body's response. (Germann et al., 2018).

Now a days low and high frequency vibration is currently used as a non-invasive treatment for bone loss in woman that suffer from postmenopausal bone weakening symptoms, children with muscular dystrophy as well as patients with cerebral palsy (Oliveira et al., 2016). And even more recently, researchers have been investigating the potential of HVF as a non-invasive and promising technique to expedite the process of tooth movement. This innovative approach has sparked significant interest within the orthodontic community. This technology is being applied in combination with orthodontic treatments with the purpose of reducing duration of treatment time, reduce pain perception levels, and have a better tray adaptation in the case of treatments which are handed with clear aligners (Takano-Yamamoto et al., 2017).

Previous studies evaluating HFV's impact in orthodontics have shown promising results, but a comprehensive understanding of the mechanisms and clinical applications of high-frequency vibration in orthodontics remains limited to date. Different findings are shown in the literature regarding the impact of orthodontic tooth movement on bone density with the aid of HFV during the treatment. Results of these studies are contradicting, while certain studies indicate a decrease in bone density around teeth subjected to orthodontic

treatment, others point to an increase in bone density. And at the same time , there are reports indicating no discernible difference between baseline and final bone density (Shipley et al., 2019).

Most adult patients express interest and readiness to begin an orthodontic treatment. However, this enthusiasm diminishes significantly when, a long treatment time period is proposed or a surgical approach is suggested when such cases require complex movements. In the following sections, we will first take a dive into the biological mechanisms underlying HFV and its effects on bone remodeling, and will then further review recent studies that have explored the use of HFV in combination with an orthodontic treatment. Finally, we will discuss the clinical implications and interest orthodontist may have and future advancements and application of this promising technique. As more commercial HFV devices arise in the market it is important to understand and evaluate the scientific background that backs up this technology with some brands advertising up to a 64% of acceleration in tooth movement (Bilello et al., 2022).

1.1. Theorical frame

1.1.1. Biology of tooth movement

The acceleration of an object depends on the mass of the object and the amount of force applied to it (NASA Glenn Research Center, 2023) and teeth are not the exception to this universal law. This is why it is crucial to understand not only the physics but the biological response behind how teeth move, and use it in order to take advantage and create better treatment plans. Aiming to control the factors we are able to alter, in order to make this motion more predictable and controlled (Cohen et al., 1972). The process of orthodontic tooth movement needs to be perfectly orchestrated, with the precise balance to create the ideal environment for diverse cells, cytokines, and intricate mechanisms to act all at once. Different orthodontic prescriptions work with altering force, angles and or surface where the force is exerted; vibration can be combined with all prescriptions and will create a path for the movement with less obstacles while generating bone for a faster retention of the desired movement (Jeon et al., 2021).

Orthodontic tooth movement relies on the response of bone and periodontal adjacent tissues to mechanical forces exerted by orthodontic appliances. Various mechanical

stimuli, such as cyclical stretch, fluid shear stress, compression, and microgravity, contribute differently to the processes of cell differentiation and proliferation crucial for bone remodeling wanted for orthodontic purposes. (Wang et al., 2018) Tooth movement takes place when there is a presence of mechanical stimuli that creates a series of biological chain reactions induced by informatory mediators including cytokines, neurotransmitters, growth factors, and arachidonic metabolites that result in a process of bone resorption on one side and bone formation in the opposite side (Impellizzeri et al., 2020).

The distance a tooth can move within certain limits, is dependent on various factors, many of which cannot be altered or controlled by the orthodontist or the appliances themselves. Orthodontists are able to control some variables such as the amount force applied directly or indirectly in order to generate a perfectly balanced microenvironment that alters blood flow in the area, but can not control the rate in which the cells in this environment react. This roughly translates to: on the side that is experiencing compression, the process of bone resorption is initiated by multinucleated osteoclasts. This resorption facilitates tooth movement in the direction of the applied force. This pressure-tension theory is the main control element that describes the mechanism by which teeth are able to move (Jeon et al., 2021). Orthodontic applied force induces the secretion of inflammatory cytokines and chemokines in the periodontium tissue. This, in effect, attracts osteoclast precursor cells to the site, where they undergo cell differentiation process through signaling pathways, with a specific emphasis on RANK-RANKL cellular activation. The consequence is the beginning of a localized sector of catabolic activity in the area, resulting in bone loss and further as a result a quicker tooth movement. (Alikhani et al., 2018)

HFV aims to reduce the time in which teeth can move a specific distance therefor decreasing average duration time of an orthodontic treatment. In general guidelines what is expected to happen in terms of physical distance is a maximum molar average translation of the teeth in the maxilla of around 2 mm per month for space closure in a rapidly growing child or 1 mm per month for space closure in a non-growing adult. This observation is inherent of the differences in the speed of orthodontic tooth movement based on age, growth patterns and bone density. Both clinically and experimentally, numerous factors have been altered in the past in order to enhance the speed of orthodontic tooth movement, some with no significant results. These efforts to reduce time and increase efficacy include minimizing friction in orthodontic appliances,

employing additional medicinal or hormonal therapies (either local or systemic), and more recently, exploring surgical corticectomy techniques just to name a few examples (Shah, 2017).

1.1.2. Vibration and bone remodeling

Vibration is described as high or low magnitude stimulation frequency oscillatory force that is identified by the frequency in Hertz (Hz) which is the number of a full up and down movement counted per second, as well as the amplitude which is the distance from the upper point of motion to the lowest point and it measured in millimeters, and lastly the direction of the oscillatory said movement which can be in the 3 planes of space (Shipley et al., 2019). Low-magnitude is measured as (LM; less than 1 g, where g = 9.81 m/s2), while HFV is (HFV; 30–60 Hz) this repeated movements, can positively influence skeletal homeostasis and stimulate an anabolic response in both weight-bearing and bone formation according to many studies (Rubin et al., 2002).

There are more in-depth studies regarding vibration in a general level regarding bigger and longer bones rather than for orthodontic purposes. Where it has been demonstrated that when employing HFV in the absence of any pathology or inflammation, there is positive osteogenic impact on both long bones and craniofacial bones. Although, in the studies focalized in the craniofacial bones there is a particular positive emphasis on alveolar bone when undergone HFV treatments. Likewise, when HFV is applied to bones during the healing process after the removal of pathology, it has been observed to prevent bone resorption and encourage bone formation in the affected areas. Notably, in both circumstances, whether HFV is applied directly to the specific site or indirectly to an adjacent area, there is an absence of triggering inflammatory mediators or an elevation in the number of osteoclasts (Alikhani et al., 2018).

The first studies regarding the efficacy of vibration applied directly to the orofacialcavity come from in vivo animal studies where, it was seen that the presence of vibrational force accelerated tooth movement by increasing cellular migration to the area. There are some theories as to why exactly bone remodeling appears to be accelerated when subjected to HFV. Understanding mechano-transduction in various fields of biology, biomechanics, and new tissue engineering, by offering insights into the way cells perceive and react to their mechanical surroundings, it equips medical professionals with additional tools to

potentially influence outcomes is essential not only in the medical aspect but also for orthodontists (Shipley, 2018).

In cellular response specific studies it has recently been also shown that HFV is able to restore and maintain bone density to optimal levels among rats with osteoporotic bone loss (Shipley et al., 2019), which is relevant in the orthodontic context in the sense that this would signify provide better retention and stability in the in the retention phase of the treatment in order to prevent dental relapse. (Mayama et al., 2022).

This apparent accelerated effect produced in tooth movement can be attributed to the following theories that fall under the umbrella of the vibration paradox:

1.1.3. Mechanical Force

HFV generates mechanical forces that are subsequently transmitted to the bones. These mechanical forces have a remarkable capability to stimulate bone cells, more specifically osteoblasts and osteoclasts, which are known to be responsible for bone formation and resorption, respectively (Salhotra et al., 2020). The mechanical stimulation initiated by HFV has the potential to activate signaling pathways within these bone cells which lead to changes in bone density and structure created by early signs of osteogenesis (Wang et al., 2018).

1.1.4. Internal fluid flow and application of shear stress

HFV-induced vibrations can create an augmented fluid flow within the bone's microenvironment. This flow is thought to induce light stress on bone cells. Fluid shear stress is known to be involved in in bone remodeling process by triggering cellular responses in the area. Specifically regarding osteocytes, which are embedded in the bone matrix along with other cells, and which have proven in past studies to be particularly responsive to stress (Pavlin et al., 2015).

1.1.5. Piezoelectric Effect

Bone is described as a piezoelectric material, which means it generates an electrical charge in response to being subjected to mechanical stress. HFV-induced vibrations may

cause changes in electrical potentials within the bone tissue. These electrical changes can influence cellular activities, including the recruitment and activation of bone-forming osteoblasts, electrons are displaced from one side of what is described as a crystal lattice to another initiated by an external force (Carter et al., 2021).

1.1.6. Enhanced Blood Circulation

HFV may be capable of promoting better blood circulation in the bone surrounding tissues. It is known that an improved blood flow can supply more oxygen and nutrients to the bone cells, facilitating their activity and supporting the remodeling process (Farouk et al., 2018).

1.1.7. Modulation of Cellular Signaling Pathways

HFV may affect various signaling pathways in bone cells, including the Wnt/β-catenin pathway, the RANKL/OPG pathway, and the BMP/Smad pathway. These pathways are crucial for regulating bone remodeling, and LFV-induced vibrations could potentially modulate their activity. Increasing pressure within the bone leads to the movement of fluid within the marrow and along the inner surface of the bone, which could expose certain types of cells like bone marrow mesenchymal stem cells (BMSCs) and bone lining cells to this fluid flow. Adjusting this pressure could potentially improve the structural adjustment of spongy bone and expose osteoblasts, this has been analyzed in mice cellular response.(Wang et al., 2022).

1.1.8. Anti-Inflammatory Effects

Some studies have suggested that HFV may possess inherent anti-inflammatory properties, and when chronic inflammation is present can inhibit the bone remodeling process expected in an orthodontic treatment. By reducing inflammation, HVF could potentially exert an indirect yet supportive influence on bone formation. The investigation of HFV's anti-inflammatory effects represents a promising future for understanding the multifaceted impact of this technology on physiological responses There exists a combined impact on the expression of pro-inflammatory molecules PGE2, IL-6, and RANKL (Gujar & Shivamurthy, 2023).

1.1.9. Orthodontics and pain

An earlier investigation emphasized that discomfort stood out as the least favored element when undergoing an orthodontic procedure, and in the fourth position the concerns and anxieties before starting an orthodontic treatment which the participants directly linked to pain. This fear of pain has implications in personal and social areas, as well as the strategy and compliance by the patients during the treatment time. Many patients have an incline for softer diets under the idea that by doing this they could minimize the pain; non the less, the intake of soft and adhesive foods is linked to the possibility of plaque and bacteria buildup and which ends in a decline of oral hygiene, given that these types of diets are higher in starch and sugar. Interestingly enough, pain makes part of a significant factor leading to the cessation or termination of the orthodontic treatment (Celebi, 2022).

The forces required for tooth movement are frequently and most generally linked with discomfort or pain expressed by the patient, as the movement itself relies on the induction of the inflammatory cascade process which can produce pain when pain threshold of patient is low. Inflammation triggers the release of various biochemical mediators responsible for the sensation of pain. The experience of pain during orthodontic treatment can vary based on various characteristics such as age, gender, psychological well-being, cultural background, and past pain encounters. As a result, pain in this context is subjective and not seen in all cases but patients can associate it with orthodontics itself. (Fleming et al., 2016). The ideal objective in orthodontic treatment is to maximize the biological response by the body while minimizing any harmful side effects and to overall reduce the treatment time (Farouk et al., 2018).

Various techniques exist to help reduce the pain caused by orthodontic treatment, although pain is not perceived equally by all patients. These methods can be divided into two types: ones involving medicine that could be intraoral or topical and others that don't, meaning that they could be mechanical or thermal. While medicines can help with pain and are usually the first line of treatment patients tend go for, some of them can negatively interfere with the natural cellular expected process of tooth movement and may lead to other health issues like bleeding disorders, allergies, ulcers, asthma, kidney problems, heart problems, atherosclerosis, and high blood pressure (Fleming et al., 2016). As a consequence of these possible side effects, researchers are now leaning towards non-medicine dependent approaches. They're studying things like vibration devices, electrical

nerve stimulation, chewing gum, low-level laser therapy, and special bite wafers to find alternatives and alleviate the discomfort for patients. (Celebi, 2022) Orthodontic practitioners have observed that patients using devices such as AcceleDent® experience not only the anticipated benefits related to orthodontic treatment but also an additional advantage of reduced discomfort and pain. With this in mind the use of a device with little to no side effects should be easily accepted by patients (Chawla et al., 2022).

1.1.10. Complex movements

There is a growing need for non-surgical interventions to manage skeletal misalignments, particularly in individuals with minimal growth or slow growth rates. Integrating commonly used technologies with recent innovative has created as a pivotal strategy in achieving outcomes previously deemed as unachievable. High-frequency vibration has introduced a novel treatment plan by facilitating stable adjustments with a tendency of reduced occurrences of relapse, this offers an alternative for borderline cases that would typically be treated with surgical intervention. (El-Bialy, 2020)

1.1.11. The device

It is crucial to understand the biological effect that pulsatile vibration can have in order to as professionals take the incentive to use them, this study aims to understand the perspective of orthodontist regarding the efficacy of intra oral HFV appliances combined with clear aligner orthodontic treatment. Companies that fabricate this appliances claim a better aligner tracking to diminish refinements after the first set of aligners as well as amount of days in which patients may changes the and a diminish in pain felt by patients who use HFV appliances during their treatment (*Propelortho*, n.d).

HFV devices are extra oral small appliances that fit comfortable in the mouth of users (orthodontic patients) and recommended to be used with aligners to avoid direct contact with brackets as they might fall and therefore slowing the overall treatment. Patients are to use HFV device every day during treatment for 5-20 minutes a day. The manufacturers claim that the correct use of this appliance can "speed up treatment time by up to 50%, may reduce discomfort, reduces office visits and may improve aligner seating " (Alansari et al., 2018). Currently propel VPRO5® and Acceledent® are the most known HFV devices in the market, with a force of 0.25 N and a frequency of 30 Hz or 120 Hz

correspondingly, depending on the device used.

As HFV devices are most commonly paired with clear aligners it is also relevant to understand de underlying advancements. Invisalign's ® latest technologies enable trays to be replaced every 7 days, in contrast with the initial 14 days, provided that patients adhere to the guidance of a minimum of 22 hours of daily usage (Align Technology, 2016). Bilelo et al. (2022) reported treatment durations underscores the necessity to wear each aligner for an average of 15.4 days when following a 14-day change routine even with the new technologies adopted. The variation from the presumed 14 days is attributed to time loss, specifically delays in scheduling appointments with the dentist. Despite being a minor variable, this factor was also factored into calculations to accurately reflect the actual treatment duration time (Bilello et al., 2022).

1.1.12. Clinical application of HFV

The thought of using mechanical approaches came from the concept that applying orthodontic force causes bone bending which develops bioelectrical potential as explained in the previews section regarding the vibration paradox. The cyclic impulses generated by these devices would generate the same bioelectric field that would allow for the ideal environment to arise faster, the concave sit will be negatively charged attracting osteoblasts and the convex site will be positively charged attracting osteoclasts. The principal behind the use of cyclic vibratory method is to place light alternating forces on the teeth via mechanical radiations. A cyclic device is used to produce the vibration impulses of 20-30 to 120 Hz for 20 minutes each day in human teeth. These vibrations stimulated remodeling activity and brought about tooth movement at the rate of 2-3 mm/month. These devices are portable so they can be charged similar to any other electronic device like an electrical toothbrush, they have a U shape to comfortably sit in the oclusal area of the patients teeth and molars creating uniform movement (*Propelortho*, nd).

Various case studies using this device have shown that treatment times could be reduced by up to 30-40 %. Acceledent ® has recently become commercially available, which brings a new device to choose from. To explore the clinical effects of this device, Nimeri et al. conducted a clinical trial in which 14 orthodontic patients were recruited and instructed to use the device for 20 minutes daily for a period of 6 consecutive months. As

a result, it was found that the total rate of movement for the mandibular arch was 2.1 mm per month and for the maxillary arch was 3.0 mm per month, which apparently is faster than the traditional finding of about 1.0 mm per month (Nimeri et al., 2013). Gadakh and his co-workers found cyclical forces between 1 Hz and 8 Hz, with forces ranging from 0.3N to 5N, increased bone remodeling (Gadakh et al., 2016).

Aligner tracking issues are present in a great number of patients and this issue leads to additional refinements needed and less predictability. The utilization of the HFV device resulted in aligner exchanges that were 64 % faster compared to the control group in the research done by Shipley in 2018. It was said that subjects in the study needed fewer refinements and aligners to finish treatment compared to those in the control groups (Shipley, 2018).

1.1.13. Contraindications

One of the main concerns about using any new approach are side effects or long-term consequences that may arise. As faster movement is expected the fear of root resorption has been considered. HFV is said to increase the rate of tooth movement and through this a prolonged exposure of roots to inflammatory mediators can occur. Research has indicated an absence of root resorption in response to vibration (Alikhani et al., 2018). Additionally, while HFV increased the number of osteoclasts, all osteoclasts were mostly situated on the alveolar bone surface rather than the root surface of teeth. This observation contradicts the notion that HFV could be a factor contributing to root resorption (Alikhani et al., 2018) Meaning that there is no down side of applying HFV to patients undergoing orthodontic treatment. Furthermore, current investigations have failed to isolate the specific impacts of vibration attributes, such as varied acceleration, resultant load bearing, frequency, and duration of the applied load. Consequently, the interpretation of the data becomes considerably challenging. Additionally, the cellular and molecular mechanisms underlying this phenomenon remain uncertain this is why it is important to see the real clinical use and perception of orthodontist. (Alikhani et al., 2012).

It is important to take into account the compliance factor witnessed in all removable patient dependent treatment options. According to several authors, adherence to the prescribed removable appliances during treatment is often associated to their convenience, likelihood of failure, and absence of discomfort of pain (Nahajowski et al.,

2022). Referring to aligners the lack of compliance can lead to mal adaption of the trays causing what is known as “non-tracking” (Alansari et al., 2018) As HFV is one more patient dependent device this factor should also be considered.

The interest of pursuing this line of investigation comes from the motivation it exists behind new technologies in the dental area. Understanding the tendencies that motivate the creation of new tools to give a better treatment to patients.

1.2. Objectives

1.2.1. Primary objective

The primary objective of this study was to analyze the current interests orthodontists may have in treatment acceleration techniques, focusing on high-frequency vibration and its possible clinical application.

1.2.2. Secondary objectives

Discuss the potential clinical applications of high frequency vibration during an orthodontic treatment.

Examine the challenges and future prospects of implementing this innovative approach in orthodontic practice.

2. MATHERIALS AND METHODS

2.1 Study Sample

The present study has previously received approval form the ethics comity of Universidad Fernando Pessoa on October 24 of 2023. An anonymous online survey was divulged to a group of practicing orthodontists in a wide variety of countries in: Europe, South America as well as North America in reference to the knowledge on combining treatment with aiding techniques such as, the use of high frequency vibration in order to accelerate treatment duration times and enhance the patients experience while undergoing an orthodontic treatment. The Questionnaire was shared with the participants that agreed to participate through e-mail containing a direct link to google forms questionnaire as well as through social media groups sharing the link in orthodontist on line groups. The questionnaire was available for orthodontists to fill out throughout the month of November 2023 and to be filled out in the language of their convenience (English, Spanish or Portuguese).

2.2. Questionnaire Design

This study was carried out using a self-administered structured questionnaire. The questions proposed to the participants where closed ended questions consisting of yes and no questions as well multiple-choice answers to better quantify the data collected in the stipulated time frame. The questionnaire consisted of 10 questions that covered the knowledge and interest of orthodontists regarding ways to reduce de duration of treatment time for their patients. The first section deals with the awareness and use of techniques to accelerate orthodontic treatment times, followed by questions regarding the confidence they have in high frequency vibration used to accelerate dental movement, and ending with questions that dealt with the interest and importance orthodontists have in regard to shorten treatment time from their point of view and from what they perceive from their patients.

The questionnaire was first produced in English and then translated into Spanish and Portuguese with the aim of reaching more clinicians in different continents. To ensure there are no discrepancies, the translated versions where back-translated into English and compared between them to avoid mal interpretation and reproduce the same question in all three languages.

2.3. Sample

The participants were chosen by purposely sampling method to ensure the participants are working as orthodontists in a dental clinic. To gain greater number of participants the inquire was send out to practicing orthodontists in various countries in Europe, South America and North America through a direct link by e mail data bases and online orthodontic groups.

2.3.1. Inclusion criteria

- Registered orthodontists
- Dentists with a clinical practice in orthodontics

2.3.2. Exclusion criteria

- Orthodontic students
- General dentists
- Any other dentists that don’t relate to orthodontic treatments.

2.4. Informed consent

The informed consent was attained by an online agreement where the participants agree to participate voluntary in the study by reading the disclosure statement and clicking "next". No personal information was obtained through the process of answering this online questionnaire.

2.5. Data extraction and statistical analysis

The analysis of the obtained responses to the questionnaire has followed the nominal or ordinal qualitative scale where responses were counted and perceptualized for their further analysis. Chi- square test was used to evaluate correlation of data obtained and its degree of significance.

2.6. Storage of data

All the information provided was given anonymously by the participants. Privacy is of utmost importance, the participation is entirely voluntary by the subjects and no personal information was recollected during the process of this pilot study questionnaire based investigation. Once the data has been analyzed the recollected information will be deleted.

3. RESULTS

This section presents the results obtained from the analysis of data collected through the pilot questionnaire conducted for this study. The responses gathered provide insights into the knowledge, use and interest orthodontists have towards the use of High Vibration Frequency. The total sample of questionnaires answered consisted of 80 subjects whom answered the questionnaire voluntarily and anonymously though a direct link shared by mail and online social platforms. Practicing orthodontists answered the questionnaire in their respective language of preference: English, Spanish or Portuguese.

Out of the 80 participants only 20 participants, have personally implemented HFV devices as part of their treatment plan have answered the full questionnaire, which entails a 25 % of the sample. With the purpose of better analyzing and grouping the data obtained the responses from the 3 languages questionnaires where unified into one single data base.

Answers given by participants who answered the online questionnaire regarding interest in HFV devices in combination with orthodontics (expressed in percentage).

Table 1. *Answers given by participants (percentual) questions in English language for the purpose of maintaining the use of one language throughout the study.*

Country where you practice as an orthodontist.	Spain	Portugal	Italy	France	United States	Colombia	Brazil	Ecuador	Guatemala	Middle East
	30%	6.3%	3.8%	1.3%	16.3%	1.3%	21.3 %	10%	1.3%	6.5%

Which of the following orthodontic techniques for accelerating an orthodontic treatment have you heard of?	Surgery	Laser	Intra oral medicine	HFV	None	Other:
	72.5%	61%	23.75%	52.5%	11.25%	31.25%

According to your	Yes	No	N/A

experience does orthodontic treatment accelerating techniques work?	59.5%	8.9%	31.6%

Have you heard of high frequency vibration to accelerate orthodontic treatments with devices such as Propel or Acceledent?	Yes	No	N/A
	55.7%	41.8%	2.5%

Have you ever used high frequency vibration devices with your patients?	Yes	No
	48.75%	51.25%

Would you keep using high frequency vibration to accelerate the treatment time?	Yes	No
	70%	30%

In a scale of 1-5 (1 being not that important and 5 being very important) how important is duration of treatment for your patients?	1	2	3	4	5
	0%	2.5%	7.5%	21.25%	68.75%
In a scale of 1-5 (1 being not that important and 5 very important) how important is duration of treatment for you?	1	2	3	4	5
	1.25%	5%	22.5%	30%	41.25
In a scale of 1-5 (1 being	1	2	3	4	5

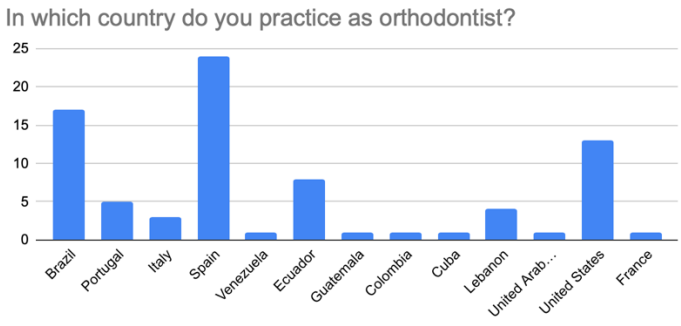
not that important and 5 very important) how likely are you to invest in tools that would decrease the treatment duration time?	2.5%	1.25%	20%	21.25%	55%
In a scale of 1-5 (1 being not that important and 5 very important) how likely are you to invest in tools that would decrease the treatment duration time?	1	2	3	4	5
	1.25%	6.25%	30%	17.5%	45%

According to your experience do you think patients would invest more money in their treatment if it were to last for a shorter period of time?	Yes	No
	72.5%	27.5%

3.1. Sociodemographic characterization of the sample

The study enlisted a cohort of orthodontists who are actively engaged in their profession, each bringing a tint of experience and expertise to the research's purpose, representing various countries across Europe, North America, and South America. The study included a total of 80 participants, and the majority of them work in different countries. More specifically, 30% of the participants work in Spain, 21.25% in Brazil, 16% in the United States, and 10% in Ecuador, among other smaller sample countries such as Portugal with 6.3%, Italy with 3.8% and France and Guatemala with 1.3%. The distribution of participants from these various countries is visually represented in Graph 1 below.

Graph 1. *Demographic of participants*



3.2. Sociodemographic knowledge of acceleration techniques for orthodontic treatments.

Overall, the vast majority of the participants had knowledge in one or other orthodontic acceleration technique in the market, only a 11,25% of the participants had absolutely no knowledge over any accelerating technique in combination with orthodontic treatments from the list provided or any other. The technique that most participants had knowledge

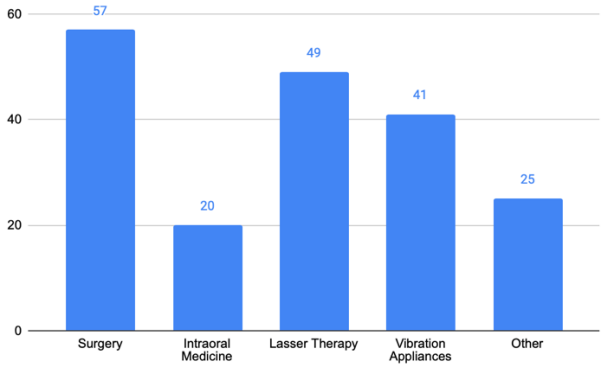
about was surgery with 73,75% of the participants having heard about this technique. In contrast with only a 48,75% that have previously heard about HFV. On the other hand, we can observe that the least known technique was intra oral medicine with only 25% of participants having knowledge about this tool, this is graphically depicted in graph 2 below.

A chi-squared test was implemented to determine if the region where de subject practices is dependent or independent from knowledge of HFV in their practice. As seen in table 1 the *p* value is .002237 where the result is significant when *p* is < 0.05. Indicating that where the subjects work has influence over the proximity of different techniques. In north America 91% of the participants have heard about HFV in contrast with Europe where only 33% of the participants had knowledge of HVF as treatment acceleration technique.

Table 2. *Chi-square test. Relationship between country and knowledge of new techniques to accelerate orthodontic treatments.*

	Knowledge of HFV	**No Knowledge of HVF**	**Totals**
South America	11 (14.25) [0.74]	19 (15.75) [0.67]	30
North America	11 (5.70) [4.93]	1 (6.30) [4.46]	12
Europe	12 (15.68) [0.86]	21 (17.32) [0.78]	33
Middle east	4 (2.38) [1.11]	1 (2.62) [1.01]	5
Totals	38	42	80

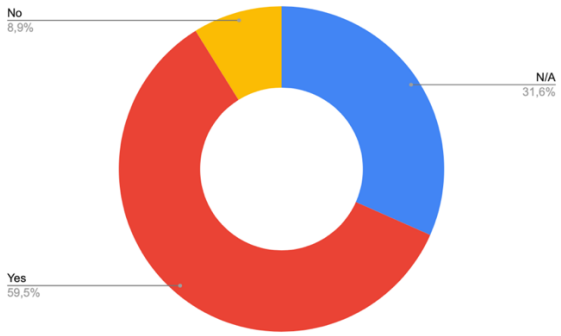
Graph 2. *Techniques knowend, stated by particpants.*



3.3. Participants confidence in accelerating techniques in combination with orthodontc treatments.

Out of the participants that have knowledge over accelerating techniques in combination with orthodontic treatment, slightly over the majority, 59.5% have confidence that the orthodontic treatment will in fact have a shorter duration when combined with one of these tools. Contrastingly, a minority faction comprising of only 8.9% of participants within this group explicitly expresses skepticism, meaning that they do not believe in the efficacy of accelerating techniques for orthodontic treatments. While 31.6% did now have any opinion about the subject as seen depicted in graph 3.

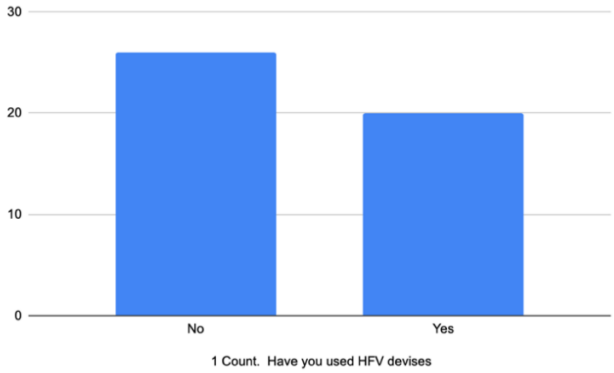
Graph 3. *Trust participants have in accelerating techniques for orthodontic treatments.*



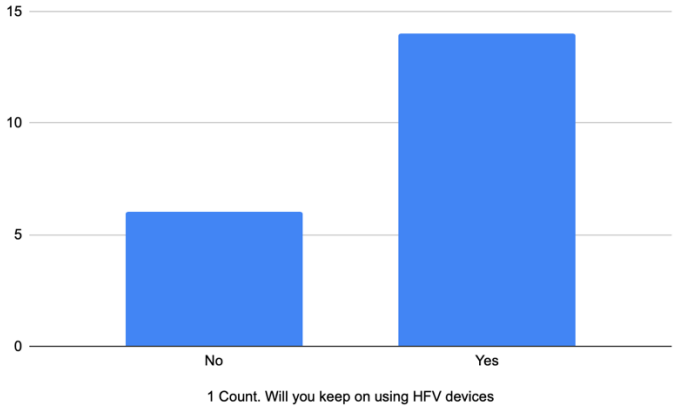
3.4 Have the participants used HFV devices with their patients before.

Among the participants who are familiar with High-Frequency Vibration (HFV) devices, which accounts for a significant 48.75% of the total participants of this study, as depicted in Graph 2, it is important to note that only 54.6% of them have actively incorporated HFV devices in combination with orthodontics in their practice, as shown in Graph 4. Out of this sub group of 54.6%, the majority, constituting 70% of the participants, express a preference for continuing to use HFV devices in conjunction with orthodontic treatments, primarily with the intention of reducing the overall treatment duration, as indicated in Graph 5. This data highlights with a substantial portion expressing a positive inclination toward ongoing implementation in orthodontic practices to enhance treatment efficiency. Although contrasting with the total amount of orthodontist surveyed (80) this accounts only for a 34.1% of the total participants.

Graph 4. *Have the participants used HFV devices with their patients*



Graph 5. *Out of the participants that have used HVF before how many will keep on using it?*

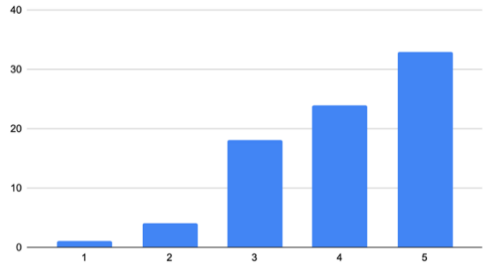


3.5 Interests shown among participants regarding HFV techniques

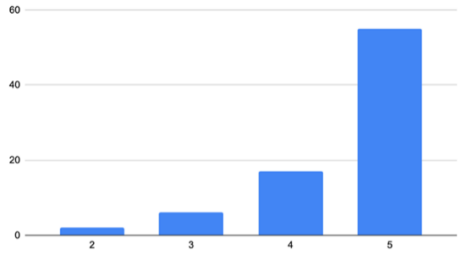
Upon thorough examination of the data in hand, it becomes clear that a significant portion of the participants places a great degree of emphasis on the time aspect of their orthodontic treatments. And only one of the participants take absolutely no regard over the duration time of their patients treatments, Graph 6.

The same can be stated for what the participants perceive from their patients experience during their orthodontic treatment. The majority of patients take great interest in the duration time of their treatment, for more than half of the participants it is very important or extremely important to have a shorter orthodontic treatment time as shown below in Graph 7.

Graph 6. *How important is for the participant to consider duration of treatment time for their patients (scale 1-5, 5 being extremely important).*



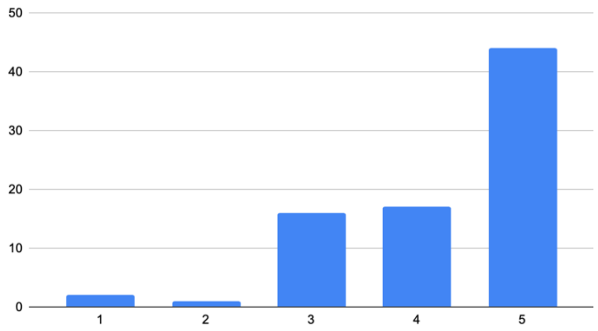
Graph 7. *How important do you consider duration of treatment time if for you. (scale 1-5, 5 being extremely important)*



3.6 Perception of participants regarding acceptance rate of orthodontic related to duration of orthodontic treatment.

The duration of orthodontic treatment assumes an important role as a potential deterrent, and acting as an impediment for prospective patients to accept treatment. This concern introduces a layer of complexity to the decision-making, where individuals contemplating orthodontic treatments may weigh the perceived length of the treatment process against other factors influencing their choice. As seen in graph 8 a great majority of the participants do believe that their acceptance rate would be positively affected by shorting the duration of orthodontic treatments proposed.

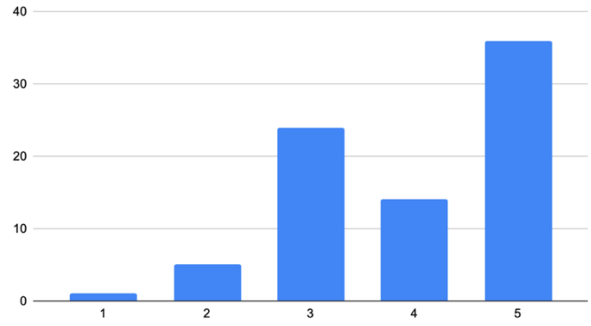
Graph 8. *Probability of acceptance rate to augment if shorter treatment times are proposed (scale 1-5, 5 being extremely likely)*



3.7 Understanding participants interest in new techniques regarding duration times of orthodontic treatments.

A 43.75% of the participants consider that is very likely for them to invest in new techniques regarding accelerating orthodontic treatments while 28.75% of participants are uncertain about whether or not they would invest in this type of auxiliary techniques knowledge, this information can be visualized below in graph 9. There are as well as some participants that are not willing to invest in learning about new technologies.

Graph 9. *How likely are you to invest in tools that would decrease the treatment duration time (scale 1-5, 5 being extremely likely).*

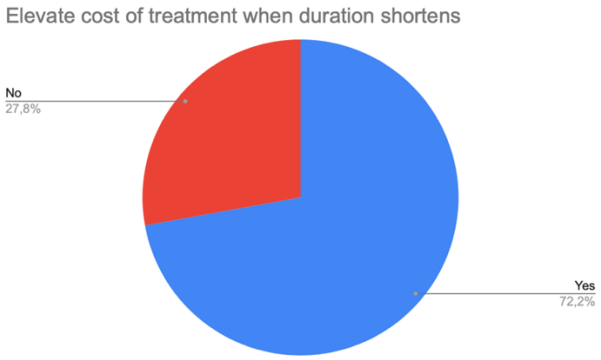


3.8 Cost of orthodontic treatment related to economical investment done by patient.

As mentioned before the duration of treatment is of great importance to participants as well as for the patients. Altering this factor would imply that the participants would be giving a greater benefit to the patients by reducing treatment time and at the same time obtaining the same results and increasing comfort level according to manufacturers. Sated

this we can clearly see in graph 10 that a 72.2% of the participants agree that when the orthodontic treatment is shorter the cost of the treatment can be augmented. 27.8% Believe that the price point would not alter when duration time of treatment shortens.

Graph 10. *Increase cost of treatment when duration of treatment is shortened.*



4. DISCUTION

It is important to reiterate that the sample size of this pilot study based on an online questionnaire consisted of 80 participants from different regions of the world, which gave us insight to tendencies adopted in different continents. In the following section we shall compare and contrast the different findings made by different studies regarding the outcome and application of HFV in combination with an orthodontic treatment in order to correct dental mal occlusions. The outcomes of said studies are very divided and this might be one of the reasons HFV has not become more popular given its lack of negative side effects as mention before. It was expected for a greater number of participants to contribute in this study taking in consideration three language options (English, Spanish, Portuguese) and the number of orthodontists contacted during the established time period.

In 2020 Conti et al. published a similar questionnaire-based study where doctors were asked about the knowledge of new techniques regarding orthodontic acceleration. The results state that the most known acceleration technique was corticotomy with 66% out of 100 participants that answered the questionnaire. In our study a similar result was obtained after analyzing the data about 73% of the participants had knowledge about surgery related acceleration techniques, followed by HFV devices with 45 % in our study while for Conti et al. (2020) only 16% of the participants had heard of this technique before. There are two theories behind these findings, the first may be related to where the participants practice as orthodontists and the second the growing interest in new technologies in the following years since the study made by Conti et al. Conti also concluded in the study that, some professionals 24% reported knowing some other (invasive) techniques but had concerns about their use in a dental practice. The orthodontists did not perform these techniques very often. Out of the known accelerating techniques used in combination with orthodontics laser therapy was the most commonly used in a clinical setting by a 7%, followed by corticotomy (6%) (Conti et al., 2020).

In a study conducted by Uribe et al. in 2014 regarding treatment duration time patients expressed their ideal orthodontic treatment times with the following results: When they were asked about how long they would like or expect their treatment to last, 40.8% of adolescent patients answered less than 6 months of treatment, while 33.2% of them answered between 6 and 12 months. On the other hand, adult patients answered that, 42.9% between 6 and 12 months, while 26.5% answered between 12 and 18 months. Results that can be directly correlated to the answers resulting from our study where

participants state that according to their perception the duration time of the treatment is extremely important for the majority of patients, they have sicked treatment. In our study it can be observed that approximately 70 % of the subjects are in agreement that time is either extremely important or very important when taking about an orthodontic treatment. Meaning that the less time they spend undergoing treatment the happier they are with the outcome. (Uribe et al., 2014).

Moresca et al. in 2018 published a study in the application of accelerating methods in orthodontic treatments and stated that the duration of orthodontic treatment is dependent on the specific malocclusion type of the patient and chosen treatment method by the orthodontist. The orthodontist's impact, patient characteristics, adherence and compliance to treatment play important roles in determining the treatment's time frame. With the efficacy of orthodontic new appliances and expedited tooth movement methods coming to play there are always more choices to provide the best treatment possible. Clinical approaches have the potential to exert control over and shorten the overall duration of orthodontic treatment when used in the correct patients, meaning that not all cases would be benefited from the use of HFV devices. (Moresca, 2018).

An interesting finding according to Alasari et al. in the study he published in 2018 regarding clear aligners as treatment option, is that even know with the implementation of smart tracking still the biggest factor affecting speed of movement are the biological factors more so than the new technology implemented in the last few years (Alansari et al., 2018). In our study it is possible to evaluate the interest participants have in creating better treatment plans by investing in new techniques which will result in modifying the impact the orthodontist has in achieving better results in a shorter time frame. A 43.75% of the participants show interest in learning new techniques in order to address this ongoing struggle given that according to Alasari et al. the key resides in the biological response.

There are many studies supporting the efficacy of HFV, Mayama et al. in 2022 observed that the number of visits necessary do in fact diminish when combined orthodontic treatment together with HFV devices. Stating that the number of estimated visits to achieve space closure in the cases analyzed was 6.38 ± 3.10 in the control group where subjects were treated with clear aligners and 4.61 ± 2.15 in the HFV device combined with clear aligners group. The number of visits in the vibration group where significantly less than that in the control group with a level of significance of $P < 0.01$. The difference

between the number of visits in the control and vibration groups was 1.77 ± 4.65 95% CI, 1.34 (Mayama et al., 2022). This results are similar to the results obtained by Shipley et al. in 2019 and by Alansari et al. in 2018 (Alansari et al., 2018; Shipley et al., 2019). Concluding with an overall positive overview if the implementation of HFV devices.

A research paper published by El-Bilay in 2020 demonstrates that the application of HFV improves treatment outcomes in challenging orthodontic cases, with severe mal occlusions where surgical solutions might typically be recommended for the case. The study's findings indicate a non-surgical enhancement of the profiles in adult and non-growing patients when orthodontically compensated. HFV devices was recommended for these individuals due to its user-friendly application and high level of acceptance rate among patients in comparison with a surgical approach. HFV has been demonstrated in prior studies to expedite orthodontic treatment, particularly when used in combination with clear aligners. This acceleration is attributed to the hypothesis that HFV helps with aligner fit and adaptation which leads to a strong adherence from the patients side (El-Bialy, 2020). Furthermore, HFV contributes to osteoblastic/osteoclastic activity in the surrounding alveolar bone, along with increased bone density under passive force. It's crucial to highlight that adults or patients who have stopped growing may require a comparatively extended treatment duration compared to individuals still in the growth phase due to the biological cellular response of the tissues (El-Bialy, 2020).

Similar results were published in 2018 during an in vivo study done in Columbia University where it was concluded that “Vibration stimulation using VPro5® for 5 minutes a day can reduce the interval between aligner change without affecting the efficiency of treatment and that vibration stimulation can increase the cytokine and bone remodeling markers in gingival crevicular fluid” (Alansari et al., 2018). This conclusion corroborates the possible positive outcome orthodontists can get by implementing HFV in their treatments, and why there is an inclination to keep on using HFV devices.

Likewise Goldeneche found positive outcomes in his study after the use of HFV which demonstrated that the use of Invisalign in association with HFV was able to significantly reduce treatment durations by 20 to 60% in aligner exchange series with 7 to 14-day standard using times between one tray and the next additionally ended up also reducing the number of expected refinements per treatment, where 77% did not require more than one refinement (Goldenéche, 2020). Which is to the same conclusion Pavlin et al. came to in 2015 when completing an in vivo study concluding that incorporating cyclic loading,

specifically vibration at a frequency of 30 Hz and a force of 0.25 N (25 g), alongside treatment using a fixed orthodontic appliance instead of clear aligners, markedly enhances the speed of orthodontic tooth movement obtaining an average translation of 0.24 mm/week in the control group while a 0.35 mm/week was reported in the in the group that used HFV (Pavlin et al., 2015).

Woodhouse in 2015 conducted a study with AcceleDent™ vibration device which was designed to enhance the process of orthodontic tooth movement. And agrees with the authors mentioned above, the study in its publication indicated its efficacy in achieving the leveling of dentition, particularly in the movement of canines during orthodontic treatment. In 2017 Liao et al. conducted a similar in vivo study but with fixed appliances instead of clear aligners and agreed with Woodhouse stating that the space closure and distalization of the canines in the vibration group were notably greater than those in the control group, whether measured intra-orally or on models ($p < 0.05$). This suggests that a single-tooth vibration at 50 Hz and 20 g can expedite the retraction of maxillary canines. Reason why a 54.6 % of the participants in our study that have used HFV devices will probably continue using them (Liao et al., 2017; Woodhouse et al., 2015).

Nevertheless, in the same study Woodhouse et al. additionally states that divergent results have been seen but focusing on other teeth (non-canines), which bring to the table a degree of inconsistency in the findings. Woodhouse et al. noted a lack of substantial differentiation in the leveling of mandibular dentition between the variable groups utilizing AcceleDent® and those not using it meaning that the total duration of the treatment would not be shortened (Woodhouse et al., 2015).

Godenèche published in 2020 in one of the most extensive in vivo case studies about this subject in particular. Published that in nearly most of the cases aligners in combination with vibration effectively reduced the intervals between appointments. This is likely to have diminished the number of dental visits by patient to the dental office, contributing to enhanced patient satisfaction and particularly in terms of the overall duration of the treatment. Only 33 % of cases reported in his study had the need to undergo a refinement phase. Although the author does state that it is hard to pinpoint with absolute certainty if what shortened the treatment times was the vibration itself or the amelioration and new technology of clear aligners (Goldenéche, 2020). Additionally, it is important to analyze patient compliance degree regarding the hours aligners where used and the frequency on which HFV device was used.

Other authors have tried to go deeper and analyze what are the modifications at a cellular level response. Reiss published one of the other few in vivo study regarding HFV and concluded that supplemental vibratory force during orthodontic treatment with fixed appliances does not affect biomarkers of bone remodeling or the RMAA. A result that contradicts the findings by Godenèche on the same year. Reiss states that the main limitation of the study was the small sample size and the large variability in the salivary biomarkers shown in the participants, his conclusions go in agreement with the study Uribe who published an article in 2017 where he concludes that higher levels of evidence studies have not been able to show an acceleratory effect in combination with an orthodontic treatment at a cellular level response (Reiss et al., 2020; Uribe et al., 2017).

Amit Khera et al. in 2022 did another extensive invitro study analyzing on a cellular level what are the consequences of HVF and the body's response. Vibration increased PGE2, RANKL, and sRANKL markers, but not OPG and Runx2 cels. Vibration had the additive effects on PGE2 and RANKL, but not as much on sRANKL in compressed PDL cells (Khera et al., 2022). However, the results were not significant enough to make a positive conclusion about his finding and can be one of the motifs of why 40% of the participants in our pilot questionnaire study do not have faith that accelerating techniques in combination with orthodontic treatments necessary work. There is a need for more studies investigating at a cellular level the changes that can be obtained from implication of HFV.

As for the study conducted by Katchooi et al. he also concludes that there is no statistically significant difference between implementing or not HFV in combination with the orthodontic treatment according to his in-vivo study. Nevertheless his study had limitations such as participation of few subjects and had no control over compliance degree (Katchooi et al., 2018).

The conclusion of numerous studies are divided and this is why it is important to reiterate the limitations described by some of the authors like Mayama et al. where as much as the author has had mildly positive out comes with the use of HFV, the study states that there is a lack of hard evidence supporting the application of HFV such as AcceleDent® under optimal vibration conditions for accelerating tooth movement. One significant challenge mentioned in the publication is that in the previous clinical studies that have been published assessing de efficacy of AcceleDent® is the uncertainty surrounding whether subjects accurately and consistently used it at home for the recommended time per day, meaning is hard to track compliance of users. As a consequence, the assessment of the

clinical efficacy and safety of AcceleDent® remains a subject of controversy among the orthodontic community (Mayama et al., 2022). A question arises as to whether the doctors that will not keep on implementing HFV devices (30%) after already testing it is due because the lack of compliance from their patients with the instructions given and time of use or lack of evidence of the technique itself when used in a clinical a setting.

According to Aljabaa et al. which did a systematic review on the subject states that because of the different methods that have been used to aces the effectiveness of HFV it is impossible to perform a correct and complete meta-analysis to compare and contrast the findings and only narrative reviews can be done on the subject. The appliances used in al in vivo studies where different which means a different force and rate of HFV is applied there for a clear analysis of the efficacity of HVF in combination with an orthodontic treatment cannot be made. Lyu et al. adds satiating that the lack of clear evidence should raise a concern among dentists regarding the application of vibration forces for long periods of time and hopes that future studies do a more meticulously design in vivo studies to better understand the real possibilities of HVF (Aljabaa et al., 2018; Lyu et al., 2019).

Now bring the attention to the possibility of decreasing relapse after orthodontic treatment. The practical implications seen in the study conducted by Alikhani et al. (2018) are very significant, as HFV is employed to accelerate orthodontic tooth movement during the phase catabolic/ active phase and later to bolster retention during the phase of rebuilding after the removal of orthodontic forces. It important to state that this study was an invitro study preformed in animal bones. Yadav et al. (2018) got similar results but they were not as statistically significant, stating that the use of a HFV device with a minimum of 30 Hz showed an incline to diminish commonly seen relapse but was not statistically significant according to Yadav (2018) which makes this study more precise since it is an in vivo animal study.

Regarding the economical investment done by patients in order to undergo an orthodontic treatment according to Conti et al. in this study published in 2020 concluded that patients are willing to invest in additional procedures in order to reduce the treatment duration time (Conti et al., 2020). The results are in agreement to question 10 of the questionnaire conducted for this study, in which doctors believe the price of the treatment should be inversely related to the duration of treatment. Orthodontists and patients both have a keen interest in speeding up the process of tooth movement, as highlighted by Uribe et al. in

their study. They found that all groups consistently showed a willingness to adopt various methods for accelerating tooth movement. Additionally, they noted that as the effectiveness of these techniques increased, so did the proportion of the orthodontic fee allocated towards them. Notably, less invasive techniques were more widely accepted among all groups (Uribe, Padala, Allareddy, and Ravindra, 2014).

The lack of larger scale and unbiased studies may be to blame when addressing the lack of interest or lack of trust in using new approaches or techniques to tackle orthodontic cases. It appears that there's a growing interest in reducing the duration of orthodontic treatment for patients from the doctors perspective as well as from the patients point of view. However, there's a requirement for a more thorough understanding over the actual efficacy of HFV which will allow orthodontists to accept new devices such as these.

Participants that took part in this study are a part of the medical community (orthodontists) and as such there is an expectation for them to continually and regularly update and invest in new information and techniques in order to stay abreast of the latest developments, advancements, and innovations within their respective field. It was surprising that only half of the participants that took part in this study seem to be interested in investing and learning about new techniques to enhance their clinical approach and solve the ongoing time limitation orthodontists face which lead to lower acceptance rates.

5. CONCLUSION

There are ongoing investigations about treatment accelerating techniques applied in combination orthodontic treatments being HFV the second most known technique among the participants of this study. The utilization of high-frequency vibration as a tool in orthodontic practice requires a more thorough and comprehensive examination to increase its use into the daily treatment plans proposed by orthodontists. This is particularly important in Europe, where a relatively lower awareness among participants was observed regarding the existence and potential applications of high-frequency vibrational devices. This process of deeper exploration is essential for ensuring that practitioners can balance out the advantages offered by high-frequency vibrational devices to optimize patient care and address time concerns brought by patients while limiting negative side effects.

Keeping in mind the further exploration of this techniques and its clinical use it would be interesting to evaluate in further investigations in which specific cases have the participants used HFV and if there is a positive correlation between diagnosis, appliances used and outcome.

5.1. Conflicts of interest

There are no conflicts of interest

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7. ANEXES

Questionnaire (English)

Questionnaire (English version) which sent through direct link to participants of this pilot study.

Use of high frequency vibration to accelerate orthodontic treatment.

ENGLISH VERSION

Thank you for taking the time to participate in our study regarding orthodontic treatments and the use of low-frequency vibration. Your valuable insights are crucial in helping us understand the experiences of orthodontist treating orthodontic cases.

In this research, we aim to better understand needs and motivation of orthodontist regarding time and duration of orthodontic treatments. Your firsthand experiences provide invaluable information that can enhance the quality of orthodontic care. By answering this questions you are helping orthodontic professionals and researchers better tailor treatments to meet patients' needs, ensuring a more comfortable and satisfactory orthodontic journey for everyone.

Rest assured that your responses will be kept confidential. All the information you provide will be anonymized and aggregated for analysis. Your privacy is of utmost importance to us, and your participation is entirely voluntary. No person al information will be recollected in the following survey.

Please take your time to answer the questions thoughtfully and honestly. There are no right or wrong answers; we are interested in your opinions and experiences. The survey should take approximately 10 minutes to complete. Once again, thank you for your participation. Your contribution is invaluable, and we appreciate your willingness to share your thoughts. If you have any questions or concerns, please feel free to contact us at 2022100443@ufp.edu.pt

By clicking **"next"** you indicate that you have read the above information and agree to participate in this study. You also confirm that you are a practicing orthodontist.

MANDATORY *

1. Country where you practice as an orthodontist *
2. Which of the following orthodontic techniques for accelerating an orthodontic treatment have you heard of? *

   _Surgery

   _Laser therapy

   _Intraoral medicine

   _Vibration appliances

   _Other

   _None
3. According to your experience does orthodontic treatment accelerating techniques work? *

   _Yes

   _No

   _N/A
4. Have you heard of high frequency vibration to accelerate orthodontic treatments with devices such as Propel or Acceledent? *

   _Yes

   _No

   _N/A
5. Have you ever used high frequency vibration devices with your patients? *

   _Yes

   _No
6. Would you keep using high frequency vibration to accelerate the treatment time?

   _Yes

   _No

7. In a scale of 1-5 (1 being not that important and 5 being very important) how important is duration of treatment for your patients ? *

8. In a scale of 1-5 (1 being not that important and 5 very important) how important is duration of treatment for you? *

9. In a scale of 1-5 (1 being not that important and 5 very important) how likely do you think your acceptance rate would increase if duration time would be shortened? *

10. In a scale of 1-5 (1 being not that important and 5 very important) how likely are you to invest in tools that would decrease the treatment duration time. *

11. According to your experience do you think patients would invest more money in their treatment if it were to last for a shorter period of time? *

_Yes

_No

Authorization by ethics comity of Universidad Fernando Pessoa

UNIVERSIDADE FERNANDO PESSOA

Exma. Senhora
Prof. Doutora Sandra Gavinha
Diretora da FCS

Nº	Data
FCS/MIMD – 446/23	24 de Outubro de 2023

Exma. Senhora Professora Doutora,

A Comissão de Ética apreciou o projeto apresentado por Dominique Melanie Tijssen, intitulado "Orthodontic movement acceleration devises during orthodontic treatment combined with aligners: professional perspective- A pilot study", a realizar no âmbito do Mestrado Integrado em Medicina Dentária.

O objetivo principal deste estudo é analisar o interesse dos ortodontistas em "vibrações de alta frequência" e sua aplicação clínica. Tem, ainda, como objetivos secundários:
- Discutir as suas potenciais aplicações clínicas.
- Examinar os desafios e as perspetivas futuras da implementação desta abordagem inovadora na prática ortodôntica.

A Comissão de Ética nada tem a opor quanto à realização deste projeto.

Com os melhores cumprimentos,

A Presidente da
Comissão de Ética da UFP
Inês Lopes Cardoso
Inês Lopes Cardoso

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