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Vibration Therapy in Accelerated Orthodontics – A Review

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A B S T R A C T

This article delves into the realm of accelerated orthodontics, spotlighting the revolutionary role of vibration therapy in expediting tooth movement. From its biological underpinnings to mechanisms, the discourse navigates through the potential benefits, addressing conventional orthodontic limitations. Focusing on vibration devices like AcceleDent , the narrative unfolds the multifaceted impact on pain perception, soft tissue discomfort, and psychological aspects. Moreover, it elucidates the integration of vibration therapy into treatment plans, exploring combination therapies and considerations for practitioners. The comprehensive overview extends to the management of side effects, patient selection criteria, and the evolving landscape of orthodontic innovations. In the future horizon, ongoing research, advancements in vibration devices, and personalized treatment approaches stand as pivotal contributors to the transformative landscape of orthodontic care.

Keywords: Accelerated orthodontics, Vibration therapy, Tooth movement, AcceleDent, Pain perception, Patient satisfaction, Combination therapies, Side effects, Orthodontic innovations, Personalized treatment.

1. Introduction

Accelerated orthodontics refers to a set of methods used to speed up the process of tooth movement during orthodontic treatment.(1)

Accelerated orthodontic treatment can provide several benefits for patients seeking enhanced oral health and aesthetics. By expediting tooth movement, treatment times can be reduced by up to 70% 1, resulting in a more efficient and comfortable orthodontic journey 9. This can also lead to a reduction in potential risks associated with conventional orthodontic care . Additionally, accelerated orthodontics can provide patients with a versatile toolkit to enhance their overall treatment outcomes.(2) Vibration therapy is a technique used in accelerated orthodontics that involves the application of gentle alternating pressures to the teeth through mechanical radiations 7. This approach has demonstrated its effectiveness by eliciting in vitro cellular responses to mechanical stress within a remarkably short timeframe of 30 minute.(2) Vibration therapy is a significant technique in orthodontic treatment because it has been shown to accelerate tooth movement 10. This can lead to a reduction in treatment times by up to 70%(2).

2. Background

Traditional orthodontic treatment refers to the use of fixed appliances, such as braces, to straighten teeth and correct misalignments. It involves the placement of brackets and wires on the teeth, which are periodically adjusted by the orthodontist to gradually move the teeth into their desired positions. Traditional orthodontics has been widely used for many years and is considered effective in improving variables that quantify the result after orthodontic treatment, according to the article you are reading (3).there are some limitations and challenges associated with traditional orthodontics, such as discomfort and pain associated with the use of braces (3).

Prolonged orthodontic treatment can have drawbacks such as increased risk of root resorption, dental caries, and gingival recession. To address these concerns, researchers have introduced various methods to accelerate tooth movement without these drawbacks. These methods include mechanical stimulation, device-assisted therapy, surgical therapy, and the use of pharmacological agents.(4)

3. Mechanisms of Vibration Therapy

A. Biological Basis of Tooth Movement:

The biological basis of tooth movement involves the remodeling of mineralized and non-mineralized paradental tissues, including alveolar bone, periodontal ligament, and gingiva. Application of orthodontic force induces an aseptic inflammatory response, altering homeostasis and microcirculation.

This triggers the release of various biological mediators, leading to cellular responses that promote bone resorption and formation in pressure and tension sites, respectively.

B. Cellular Responses to Mechanical Vibration:

Mechanical vibration influences osteogenesis by increasing the commitment of periodontal ligament stem cells to the osteogenic lineage. Studies show enhanced protein levels of transcription factors (RUNX2 and OSX) under ultrasound stimulation. Low-intensity pulsed ultrasound (LIPUS) is highlighted as a clinically established intervention that accelerates orthodontic tooth movement by increasing osteoclast activity and potentially preventing blood flow obstruction and hyalinization at compression sites.

C. Bone Remodeling and Vibration Therapy:

The text emphasizes the role of bone remodeling in tooth movement, involving chemotaxis, cell proliferation, differentiation, and extracellular matrix synthesis. LIPUS stimulation, an FDA-approved intervention for bone growth, is discussed in the context of accelerating orthodontic tooth movement. The therapy is suggested to minimize orthodontically induced tooth root resorption by enhancing dentine and cementum deposition.

D. Effects on Orthodontic Tooth Movement:

Orthodontic tooth movement is closely linked to the response to applied forces causing the remodeling of periodontal tissues, especially alveolar bone. The text reiterates the potential benefits of LIPUS in accelerating tooth movement by increasing osteoclast activity and preventing root resorption. It also suggests that the prolonged use of laser irradiation and early introduction of laser therapy may have therapeutic benefits in abbreviating treatment time, although further studies are needed to assess dosage effects.

Vibration devices to accelerate orthodontic tooth

The use of vibration devices to accelerate orthodontic tooth movement is Low-Frequency Pulsatile Forces" and "Comparison of Different Vibration Devices"(6) short durations of low-magnitude, high-frequency resonance vibration combined with orthodontic force can increase the rate of orthodontic tooth movement without additional tissue damage in humans.

Acceledent devices

It is a commercially available, vibration device that uses soft pulse technology and cyclic forces to accelerate the movement of teeth. This device delivers a vibrational frequency of 30 Hz and requires 20 minutes per day user wear time. Several early studies on the AcceleDent device seemed to demonstrate higher rates of orthodontic tooth movement than the established norms. (6)

Mechanisms of Pain and Discomfort Reduction

Pain Perception in Orthodontic Treatment

Pain perception in orthodontic treatment is a subjective experience that varies among individuals (7). Factors such as age, gender, pain threshold, applied force, emotional state, stress, cultural differences, and previous pain experiences can influence the level of pain felt during orthodontic procedures. Studies have shown that a significant percentage of orthodontic patients experience pain during treatment, with some individuals reporting pain at each step of the process. The forces applied to the teeth during orthodontic treatment trigger an inflammatory response, leading to pain and bone resorption, which are essential for tooth movement.

To alleviate pain during orthodontic treatment, various management strategies are employed. These include the use of analgesics, non-steroidal anti-inflammatory drugs (NSAIDs), low- level laser therapy, transcutaneous electrical nerve stimulation (TENS), and vibratory stimulation of the periodontal ligament. Among these methods, NSAIDs are commonly preferred for pain control related to fixed orthodontic appliances. Analgesics and anesthetic gels are also used to reduce pain during orthodontic procedures such as band placement, archwire ligation, and bracket removal.

It is important for orthodontists to address pain-related concerns and provide appropriate pain management strategies to improve patient comfort and compliance during orthodontic treatment. Further research is needed to streamline the use of analgesics and NSAIDs, ensuring effective pain relief while minimizing potential adverse effects.

Analgesic Effects of Vibration Therapy

Therapy has been found to have analgesic effects on pain (8). In a study conducted on human subjects, low intensity mechanical and thermal skin stimuli were used to determine their interference with pain sensation. The study found that vibration therapy, specifically intense 200 Hz vibration, had an analgesic effect on pain induced by intraneural electrical stimulation.

The analgesic effect of vibration therapy was observed to be fairly well restricted to the area under the vibrator. This suggests that the stimulation of rapidly adapting (RA) mechanoreceptors, which are activated by mechanical stimuli within small receptive fields, may contribute to the analgesic effect. However, the study does not exclude a possible contribution to analgesia from Pacinian afferents.

In addition to vibration therapy, other non-vibratory mechanical stimuli such as sustained pressure and brushing of the skin, as well as cooling, were found to have some analgesic effect. Cooling of the skin from 30 to 20°C by ether evaporation was particularly effective in relieving pain. These stimuli were found to activate cold receptors and different types of slowly adapting mechanoreceptors.

The study suggests that activity in a range of low threshold mechanoreceptive and cold sensitive units can suppress pain at central (probably segmental) levels. However, the analgesic effects of warming were inconsistent in the experiments.

Overall, vibration therapy and other mechanical and thermal stimuli have been shown to have analgesic effects on pain. The specific mechanisms behind these analgesic effects are not fully understood, but it is believed that the activation of certain types of mechanoreceptors and cold receptors play a role in suppressing pain. Further research is needed to fully understand the potential of vibration therapy as an analgesic treatment.

Reduction of Soft Tissue Discomfort

the application of resonance vibration might accelerate orthodontic tooth movement via

enhanced RANKL expression in the periodontal ligament without additional damage to periodontal tissues such as root resorption (9). This could potentially lead to shorter treatment times and less burden on the patient. It is possible that the reduction of treatment time could also lead to a reduction in soft tissue discomfort.

Psychological Aspects and Patient Satisfaction

Patient satisfaction is a crucial aspect of orthodontic treatment(10). Several psychological factors influence patient satisfaction, including the doctor-patient interaction, communication, and the orthodontist's behavior. Patients expect a comfortable and warm doctor-patient interaction, with a technically competent orthodontist who provides adequate information about the problem and procedures. When these expectations are not met, patients may feel disappointed, less satisfied, and may fail to comply with prescribed instructions.

Studies have shown that orthodontists' behaviors, such as politeness, verbal communication, and showing interest in the patient's concerns, play a significant role in influencing patient satisfaction. Polite and courteous behavior, along with reassurance and concern, are important factors that contribute to patient satisfaction. Additionally, the orthodontist's calm and confident attitude and an unhurried approach to treatment can increase patient satisfaction.

It is essential for orthodontists to have a comprehensive understanding of their patients' psychological status and motives for treatment. Effective communication and a positive orthodontist-patient relationship can enhance patient satisfaction and improve treatment outcomes. By addressing the psychological aspects of orthodontic treatment, orthodontists can provide a more holistic and patient-centered approach to care.

Considerations for Orthodontic Practitioners

Patient Selection Criteria for Vibration Therapy

Vibration therapy targets specific patient groups and health conditions:

Ideal for postmenopausal women, the elderly, and those at risk of osteoporosis due to inactivity or certain medical conditions. It aids in improving bone density and strength(11).

Beneficial for patients in physical therapy for musculoskeletal injuries, athletes seeking strength and flexibility improvement, and those with muscle weakness or compromised balance requiring rehabilitation.

Helpful for patients with neurological disorders such as Parkinson's disease, multiple sclerosis, or stroke survivors, aiding in enhancing muscle coordination and function.

Suited for individuals experiencing muscle soreness, stress, or seeking a non-invasive massage treatment. It's sought by those with chronic pain conditions for relief.

Vibration therapy is not advised for patients with acute fractures, thrombosis, acute inflammatory conditions, infections in the targeted area, pregnant women in the trunk area, or individuals with implanted medical devices.

Patient selection should consider individual medical history, health status, and specific contraindications. A healthcare professional, such as a physician or physical therapist, should evaluate suitability based on an individual's health condition and needs.

Integration of Vibration Therapy into Treatment Plans

Vibration therapy has shown potential benefits in orthodontic treatment plans(12). By incorporating high-frequency vibration (HFV) devices into treatment, orthodontists can enhance tooth movement and promote bone density.

Research has demonstrated that HFV can accelerate tooth movement when used adjunctively with orthodontic force. The mechanical stimulation delivered by HFV amplifies the rate of bone remodeling, resulting in faster tooth movement. Additionally, HFV has been shown to increase cytokine IL-1b levels, which supports accelerated tooth movement by activating osteoclasts.

Furthermore, HFV has an anabolic effect on bone density. Studies have shown that HFV can restore bone density to pre-disease levels in osteoporotic alveolar bone. The frequency and magnitude of vibration play a crucial role in bone cell response, with higher frequencies demonstrating enhanced sensitivity and bone formation rates.

Incorporating vibration therapy into treatment plans can be done by using LFV (low- frequency vibration) or HFV devices. LFV devices operate at frequencies of ⩽45 Hz, while HFV devices operate at frequencies of ⩾90 Hz. The choice of device depends on the desired outcome and the specific needs of the patient.

By integrating vibration therapy into treatment plans, orthodontists can potentially accelerate tooth movement, enhance bone density, and improve treatment outcomes. However, further research is needed to fully understand the optimal protocols and long-term effects of vibration therapy in orthodontic treatment.

Combination Therapies: Vibration with Pharmacological Agents

Combining vibration therapy with pharmacological agents has shown promise in enhancing orthodontic tooth movement(13). Vibratory devices, such as AcceleDent, when used in conjunction with pharmacological agents, can potentially accelerate the rate of tooth movement and improve treatment outcomes.

Studies have demonstrated that low-frequency vibrations stimulate cellular activity in the periodontal ligament, increasing the number of osteoclasts and promoting bone remodeling. This, in turn, can lead to faster tooth movement. When combined with pharmacological agents, such as bisphosphonates or prostaglandin analogs, the synergistic effect can further enhance the rate of tooth movement.

However, it is important to note that the evidence supporting the effectiveness of combination therapies is still limited. Further research, including randomized controlled trials, is needed to establish the optimal protocols, dosages, and duration of treatment for different combinations of vibration and pharmacological agents.

Management of Side Effects and Risks

Accelerated orthodontics techniques have gained interest in recent years due to their potential to reduce treatment time(14). However, it is important to consider and manage the potential side effects and risks associated with these techniques. Here are some key considerations for managing side effects and risks:

Root Resorption: Root resorption is a common concern in orthodontic treatment, and it is unclear whether accelerated orthodontics techniques increase the risk. To minimize the risk, careful case selection and treatment planning are crucial. Regular monitoring of root resorption during treatment and follow-up is essential. If significant root resorption is detected, treatment adjustments may be necessary.

Gingival Inflammation: Accelerated orthodontics techniques can cause temporary gingival inflammation. Proper oral hygiene instructions and regular professional cleanings can help manage and prevent gingival inflammation. Patients should be educated on maintaining good oral hygiene practices throughout treatment.

Decalcification and Dental Caries:

Shortened treatment time may reduce the risk of decalcification and dental caries(15). However, maintaining good oral hygiene and regular dental check-ups are still essential to prevent these issues. Patients should be advised on proper brushing and flossing techniques and encouraged to follow a healthy diet that minimizes sugary and acidic foods.

Patient Selection: Not all patients are suitable candidates for accelerated orthodontics techniques. Careful evaluation of the patient's oral health, skeletal discrepancies, and treatment goals is necessary. Patients with severe skeletal discrepancies or compromised periodontal health may not be suitable candidates for these techniques.

Long-term Stability: The long-term stability of accelerated orthodontics outcomes is still an area of ongoing research. Patients should be informed about the potential need for retention and the importance of compliance with retention protocols to maintain the achieved results.

Ongoing Research: As accelerated orthodontics techniques continue to evolve, ongoing research is necessary to evaluate their long-term effects and potential risks. It is important for orthodontic professionals to stay updated with the latest research findings and incorporate evidence-based practices into their treatment protocols.

4. Considerations for Orthodontic Practitioners

A. Integration of Vibration Therapy into Treatment Plans

When integrating vibration therapy into orthodontic treatment plans, practitioners should consider the following:

1. Treatment goals: Determine if the use of vibration therapy aligns with the treatment goals for the patient. Vibration therapy is primarily used to accelerate tooth movement, so it may be beneficial for patients who desire shorter treatment times or have specific time constraints.

2. Patient compliance: Assess the patient's ability to comply with the recommended use of the vibration device. Vibration therapy typically requires daily use for a specified duration, so it is important to ensure that the patient is willing and able to incorporate it into their daily routine.

3. Treatment stage: Consider the stage of orthodontic treatment when introducing vibration therapy. It may be more effective to incorporate vibration therapy during specific phases, such as initial alignment or space closure, where accelerated tooth movement is desired.

4. Device selection: Choose a vibration device that is suitable for the patient's needs and preferences. Consider factors such as device comfort, ease of use, and compatibility with the orthodontic appliances being used.

5. Treatment duration: Determine the duration of vibration therapy based on the individual patient's needs and treatment plan. This may vary depending on the desired rate of tooth movement and the specific orthodontic case.

6. Monitoring and adjustments: Regularly monitor the progress of tooth movement and assess the effectiveness of vibration therapy. Adjust the treatment plan as needed based on the patient's response to the therapy.

7. Patient education: Educate the patient about the benefits and expectations of vibration therapy. Provide clear instructions on how to use the device properly and address any concerns or questions the patient may have.

8. Follow-up and evaluation: Schedule regular follow-up appointments to evaluate the progress of tooth movement and assess the effectiveness of vibration therapy. This allows for adjustments to be made if necessary.

By considering these factors, orthodontic practitioners can effectively integrate vibration therapy into treatment plans and optimize the outcomes for their patients.(6)

Management of Side Effects and Risks

Pain Control: A device that vibrates at a frequency of 100 Hz to 250 Hz and a force of approximately 100g or 1N has been used to reduce pain associated with orthodontic adjustments. This device has shown significant reduction in pain without any reported adverse events.

Root Resorption: Studies have shown that vibrations at a frequency of 60 Hz can increase tooth movement and potentially reduce root resorption. In a rat model, the group that received vibration had a statistically significant increase in tooth movement compared to the group that only received static force. Additionally, the vibration group showed a trend towards less root resorption.

Bone Architecture: Cyclic forces, such as vibrations, have been found to accelerate bone remodeling compared to static or intermittent forces. While intermittent forces are still static forces, cyclic forces have been shown to enhance and speed up tooth movement. However, it should be noted that the use of pulsating force devices for enhancing tooth movement has not been introduced commercially.

Pharmacological Approaches: Pharmacological approaches, such as the injection of prostaglandins and peptide hormones around the teeth, have been used to enhance tooth movement. However, these approaches come with their own set of problems, including pain, severe root resorption, and drug-induced side effects.

In conclusion, the management of side effects and risks in orthodontic treatment using vibrations involves pain control, monitoring and minimizing root resorption, understanding the effects on bone architecture, and considering alternative pharmacological approaches.(16)

5. Future Directions and Innovations

A. Ongoing Research in Vibration Therapy

1. High frequency, low magnitude vibration: Research is being conducted to explore the effects of high frequency, low magnitude vibration on orthodontic tooth movement. This type of vibration aims to accelerate periodontal and bony tissue remodeling, potentially reducing treatment time and discomfort for patients.

2. Acceledent device: The Acceledent device, developed by Dr. Jeremy Mao, is a novel innovation in vibration therapy. It uses pulsating forces to enhance bone remodeling and increase the rate of tooth movement during orthodontic treatment. Clinical trials are being conducted to evaluate its effectiveness and safety.

3. Pain management: Vibration therapy is also being studied for its potential in reducing pain associated with orthodontic adjustments. By applying vibration to the teeth and surrounding tissues, it is hypothesized that the perception of pain can be diminished, improving patient comfort and compliance with treatment.

4. Safety and efficacy: Ongoing research aims to further investigate the safety and efficacy of vibration therapy in orthodontics. Studies are being conducted to assess the impact of vibration on root resorption, tissue hyalinization, and overall treatment outcomes.

5. Whole body vibration: While not specific to orthodontics, whole body vibration is another area of research in vibration therapy. It involves the use of vibrating platforms to stimulate muscle performance, balance, and mobility. Studies are exploring its potential benefits for musculoskeletal development and fracture prevention(17)

B. Potential Advancements in Vibration Devices

There are several potential advancements in vibration devices that could enhance their effectiveness in orthodontic treatment. Some of these advancements include:

1. Improved frequency and magnitude control: Vibration devices could be designed to provide more precise control over the frequency and magnitude of vibrations. This would allow orthodontists to tailor the treatment to each individual patient's needs and optimize the acceleration of tooth movement.

2. Wireless and portable devices: Currently, most vibration devices are wired and require a power source. The development of wireless and portable devices would make it more convenient for patients to use the device at home or on the go, increasing compliance and treatment effectiveness.

3. Smart technology integration: Incorporating smart technology into vibration devices could provide real-time feedback and monitoring of treatment progress. This would allow orthodontists to track tooth movement and make adjustments as needed, leading to more efficient and effective treatment outcomes.

4. Multi-directional vibrations: Current vibration devices typically provide vibrations in a single direction. Advancements in technology could allow for multi-directional vibrations, which could potentially enhance the stimulation of periodontal tissues and accelerate tooth movement.

5. Combination therapy: Vibration devices could be combined with other orthodontic treatment modalities, such as low-level laser therapy or corticotomy, to further enhance the acceleration of tooth movement. This combination therapy approach could potentially provide synergistic effects and improve treatment outcomes.

Overall, advancements in vibration devices have the potential to revolutionize orthodontic treatment by significantly reducing treatment time and improving patient satisfaction. Continued research and development in this area will likely lead to exciting innovations in the future.(18)

C. Personalized Orthodontic Treatment Approaches

Personalized orthodontic treatment approaches using vibrational therapy involve incorporating vibrational devices or techniques into the treatment plan to enhance the orthodontic outcomes for individual patients. Here are some examples:

1. Vibrational Devices: Orthodontic treatment can be supplemented with the use of vibrational devices, such as AcceleDent or VPro5. These devices deliver low-frequency vibrations to the teeth and surrounding tissues, which can accelerate tooth movement and reduce treatment time. The orthodontist will determine the appropriate device and treatment protocol based on the patient's specific needs.

2. Resonance Vibration: Resonance vibration involves applying vibrations at specific frequencies to the teeth or orthodontic appliances. This technique aims to stimulate bone remodeling and enhance the rate of tooth movement. The orthodontist will determine the appropriate frequency and duration of vibration based on the patient's individual response and treatment goals.

3. Personalized Treatment Plans: Orthodontists may customize the use of vibrational therapy based on the patient's specific orthodontic needs. For example, patients with a longer treatment duration or difficult tooth movements may benefit from incorporating vibrational therapy to accelerate tooth movement. The orthodontist will assess the patient's case and determine if vibrational therapy is suitable and how it can be integrated into the treatment plan.

4. Combination Therapy: Vibrational therapy can be combined with other orthodontic techniques to optimize treatment outcomes. For instance, it may be used in conjunction with clear aligners or traditional braces to enhance the effectiveness of tooth movement. The orthodontist will determine the most appropriate combination therapy based on the patient's specific needs and treatment goals.

5. Monitoring and Adjustment: Throughout the treatment process, the orthodontist will closely monitor the patient's progress and make any necessary adjustments to the vibrational therapy protocol. This ensures that the treatment remains personalized and tailored to the patient's individual response and progress.

It's important to note that the use of vibrational therapy in orthodontics is still an evolving field, and research is ongoing to further understand its effectiveness and optimal application. Orthodontists will consider the patient's specific needs, treatment goals, and clinical evidence when incorporating vibrational therapy into personalized treatment plans.(19)

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