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(REVIEW ARTICLE)

Comparison of the efficacy of pulsed ultrasound and laser in tooth movement: A literature review

Doménica Sofía Celi Cárdenas [1,*], Kassandra Elizabeth Sigüenza González [1], Juan Sebastián Fernández Ochoa [1] and María Yolanda Yunga Picón [2]

[1] *Faculty of Dentistry of the University of Cuenca. Cuenca, Ecuador.*
[2] *Chair of Orthodontics, Faculty of Dentistry, University of Cuenca. Cuenca, Ecuador.*

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Abstract

When orthodontic treatment is performed, several cells responsible for bone remodeling are stimulated, including fibroblasts, osteoblasts, osteoclasts, and other cells. Bone remodeling is essential as it allows us to move dental pieces from their original position to the desired location within the dental arch, correcting malocclusion, achieving functional occlusion, and, in some cases, enhancing facial harmony. One reason why patients may hesitate to undergo orthodontic treatment is the long duration, typically spanning 24 to 36 months (2-3 years). Currently, new techniques have been developed to reduce treatment time, periodontal inflammation, hyalinization and intense pain. These techniques can be classified into three categories: 1) Biochemical stimuli, 2) Mechanical or physical, and 3) Surgical intervention. A thorough search of current literature was conducted across various scientific sources to explore this topic. The objective of this literature review is to compare the effectiveness and efficiency of laser and pulsed ultrasound techniques in tooth movement. By examining the advantages and disadvantages of each physical technique, we aim to determine the most suitable and minimally invasive approach to bone remodeling, ultimately reducing orthodontic treatment time while ensuring effective tooth movement without causing unwanted pain or adverse effects for the patient.

Keywords: Orthodontic Movement; Laser; Pulsed Ultrasound; Bone Remodeling; Photobiomodulation.

1. Introduction

Orthodontic tooth movement is a biological process that, by means of the application of force, can move one or a group of teeth without affecting adjacent structures, to align them or take them to their correct position in the dental arches. For this movement to occur, bone remodeling must exist, that is, both bone resorption and bone apposition. (1) (3) (6)

Currently, most patients reject orthodontic treatment because of its long period, which is usually 2-3 years (1) (5) (6), so several theories of tooth movement have been developed to reduce the treatment time, which are minimally invasive and without harmful effects on adjacent tissues. (3)

Some of the techniques for achieving tooth movement are shown in Table 1 (4). 2 of the physical mechanisms, which are ultrasound (LIPUS) and laser (LLLT), will be studied.

* Corresponding author: Doménica Sofía Celi Cárdenas

Table 1 Classification of dental movement techniques

1	Biochemical stimuli
1.1	Parathyroid hormone
1.2	Osteocalcin
1.3	Prostaglandin
1.4	Dihydroxyvitamin D3
2	Mechanical or physical
2.1	Mechanics
2.1.1	Low friction mechanics
2.1.2	Self-ligating brackets
2.1.3	Microimplants
2.1.4	Preformed arches
2.2	Physical
2.2.1	Micropulse and cyclic vibration
2.2.2	Láser de bajo nivel
2.2.3	Ultrasonido pulsátil de baja intensidad
3	Surgical intervention
3.1	Corticotomy
3.2	Osteogenic orthodontics assisted by periodontics
3.3	Orthodontics assisted by piezocision.

1.1. Low-Level Laser Therapy (LLLT)

Low-Level Laser Therapy (LLLT) stimulation is the application of light found in the range of 600 nm to 1000 nm (4). Generally, it is based on the Arndt-Schultz principle, which states that "low doses of any substance or drug have a stimulatory effect, while higher doses have an inhibitory effect." The laser's operating mode is based on two determinants: 1) type of absorption and 2) wavelength responsible for the penetrating depth, and its effect is non-invasive. (5)

It is applied to reduce discomfort and pain that occurs from applying orthodontic appliance forces to the tooth. LLLT, through its electromagnetic waves, stimulates the mitochondria of cells and the energy cycle, thereby accelerating cell function (5). In vitro studies have shown that LLLT accelerates bone healing, improves and stimulates osteoclastic activity, and increases the proliferation of osteoblasts and osteoclasts, accelerating bone remodeling and increasing the efficiency of tooth movement. It also stimulates nerve regeneration, and irradiation improves the renewal of connective tissues without affecting the periodontal tissues (4), but it does not have a significant effect on osteoblasts. (1)

LLLT is used in several branches of modern dentistry, such as: reduction of bacteria during endodontic therapy, removal of caries, management of dentin hypersensitivity, treatment of reduction of inflammation in periodontics, improvement of bone repair and osseointegration in implantology. In the field of orthodontics, it is used for reducing pain during treatment and accelerating dental movement. (4)

1.2. Pulsed Ultrasound (LIPUS)

On the other hand, Pulsed Ultrasound (LIPUS) is an acoustic pressure wave with frequencies above the human audible limit, meaning its intensity is between 30 mW/cm2 to 100 mW/cm2, transmitted by and towards biological tissues (1). Physical vibration stimulates a natural functional movement around the cell membrane and it is widely used as a non-invasive therapeutic tool to aid tissue biological healing (6).

LIPUS has a low heat effect on specific areas (6), stimulates key functional activities of osteoblasts in bone, can even help in human mandibular growth, reduces root resorption, increases stimulation of cement and predentin formation (1) and increases the number of subodontoblastic cells. LIPUS has a greater effect on osteoblasts, periodontal ligament regeneration, dentin-pulp repair, and improves blood circulation, aids in implant osseointegration, and has effects on TMJ diseases (6). With its use alone, LIPUS can accelerate treatment by 49%, and with the patient's cooperation, it can increase up to 66% with the use of clear aligners (6). One disadvantage of LIPUS is that it affects osteogenic cells, leading to the creation of mineralized nodules (1) and may have an effect on postmenopausal women (6).

There are few differences found between laser and pulsed ultrasound as can be observed in Table 1. However, studies have shown that together they have a greater effect on orthodontic movement. (1)

Table 2 Comparison between laser and pulsed ultrasound

Effect	**LLLT**	**LIPUS**
Non-invasive	yes	yes
Decreases pain	yes	yes
Bone repair	yes	yes
Accelerates healing	yes	yes
Increased activity on osteoclasts	yes	no
Increased activity on osteoblasts	no	yes
Connective tissue remodeling	yes	yes
Speeds up tooth movement	yes	yes
Affect osteogenic cells	no	yes
Improves mandibular growth	yes	yes
Reduces root resorption	yes	yes
Stimulates cement and predentine formation	yes	yes
TMJ cartilage regeneration	yes	yes
Dentino-pulp repair	yes	yes
Stimulates natural functional movement around the cell membrane	no	yes
Stimulates the mitochondria of the cell and accelerates the energy cycle	yes	no
Increased the number of subodontoblastic and periodontal ligament cells	yes	yes
Improves blood circulation	no	yes

2. Materials and methods

The primary sources for the research were articles that were 10 years old or less. Keywords were used in both Spanish and English, such as "pulsed ultrasound", "laser", "tooth movement", "orthodontics", and "effectiveness", to obtain the most relevant studies. A comprehensive search was carried out on digital databases such as PubMed, Scielo, MedlinePlus, Journal of Oral Rehabilitation, Google Scholar, ELSEVIER, Scopus, BVS, Embase, and Scopus, using the previously defined search terms, with the aim of identifying relevant studies published up to the year 2023. The search criteria and the results obtained were recorded.

Clear inclusion and exclusion criteria were established to select relevant studies, prioritizing those that specifically focused on the use of pulsed ultrasound and laser in tooth movement. Studies that did not meet pre-defined selection criteria and those over 5 years old were excluded, with the exception of primary sources. The pre-defined inclusion and exclusion criteria were applied to select relevant studies.

The most relevant data from the selected studies were extracted, and proper syntheses were conducted. A comparative analysis of the results obtained regarding tooth movement using pulsed ultrasound and laser was carried out.

Finally, the selected studies were independently evaluated by at least two reviewers to determine their methodological quality and the risk of bias.

3. Discussion

The application of LIPUS for 20 minutes a day, for a maximum period of six months, resulted in an increase in tooth movement speed and a reduction in orthodontically induced root resorption. (7) A recent clinical trial carried out in human patients demonstrated that intermittent use of LIPUS on days 0, 3, 5, 7, 14, and then every 15 days resulted in a higher rate of tooth movement. However, it is important to note that the LIPUS device used in this study was applied externally, and the operator placed it on the side of the patient's mouth. (8)

The statistically significant reduction in root resorption when using LIPUS is consistent with previous research (9). This may be attributed to the inhibitory effect of LIPUS on cementoblast formation, modification of OPG/RANKL expression during the orthodontic tooth movement process, and improvement in tissue regeneration, facilitating periodontal healing. (10,11,12). Cone beam computed tomography (CBCT) is the only type of radiography capable of evaluating dental movement and root length in three dimensions.

Low Level Laser Therapy (LLLT) has been shown to generate positive effects in the practice of orthodontics. A significant impact was observed in pain relief, tooth movement, and root resorption, as evidenced in the included studies. These findings are in line with previous literature, which suggests that LLLT probably has a beneficial effect on healing, nerve regeneration, the inflammatory process, pain reduction, osteoblast proliferation, bone remodeling, root resorption, and tooth movement. (13, 14, 15, 16)

4. Conclusions

After exhaustively reviewing the scientific literature, it has been concluded that both Low Level Laser Therapy (LLLT) and Low-Intensity Pulsed Ultrasound (LIPUS) have a significant impact on orthodontic treatments. These therapies offer several benefits, such as improving orthodontic tooth movement, upregulating tissue gene expression, promoting bone remodeling, and increasing patient satisfaction by reducing pain and accelerating physiological processes of remodeling, bone turnover, and cellular metabolism. As a result, it has been observed that both LLLT and LIPUS can expedite the orthodontic treatment process by 2 to 3 months, demonstrating significant effects in just 3 weeks. These therapies are considered innovative therapeutic options due to their ability to promote periodontal tissue regeneration and remodeling when applied simultaneously.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to disclose.

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