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Effects of Low-Level Laser Therapy (LLLT) On the Rate of Orthodontic Tooth Movement- A Review

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***Abstract**: Low-level laser therapy (LLLT) was introduced in orthodontics with its initial purpose to alleviate the pain following the adjustment of the different appliances and also to help speed up the healing process of a sore spot if caused by appliance impingement. Recently, studies have showed that LLLT help in the differentiation of cells taking part in the bone remodelling process and therefore seems to affect the rate of orthodontic tooth movement although the results of which have seemed to be controversial. This present article reviews the previous studies on the effects of LLLT on the rate of orthodontic tooth movement in animals as well as human subjects, and thereby aims to set an optimal protocol for the use of LLLT to accelerate tooth movement in the orthodontic field.*

***Keywords**: LLLT, Bio-stimulatory*

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I. Introduction

Generally, the fixed orthodontic appliance treatment currently in use takes 2-3 years with an increased risk of dental caries, gingival inflammation and root resorption. The tooth movement by the present orthodontic systems takes place by remodelling the periodontal tissues surrounding the teeth. Various new procedures such as osteotomy and corticotomy have been used to accelerate the tooth movement but these techniques involve raising a full thickness flap and extensive alveolar decortication. Low-level laser therapy (LLLT) or also known as cold/soft laser therapy have suggested to accelerate tooth movement by its bio-stimulatory effect. The present article reviews the existing literature of the effects of LLLT on the rate of orthodontic tooth movement.

II. Low-Level Laser Therapy

The different effects of laser beams on tissuesrange from bio stimulation to micro-explosion. Researchers have been studying the bio-stimulatory effects of low-level laser radiation since 1966[1]. In orthodontics, it can be used for the reduction of post-adjustment pain[2], bone regeneration in the mid-palatal suture area after rapid maxillary expansion[3] and acceleration of tooth movement.[4]

Orthodontic tooth movement occurs as a response of the connective tissue in which several inflammatory mediators, cytokines, and cells, participate. Low-level laser therapy (LLLT) is known as a stimulator of the on-going biological process in tissue and has been found to be effective in modulating cell activity and production of endogenous molecules, which are also involved in orthodontic tooth movement.[5]

The low-intensity laser device is usually an infrared gallium-aluminum-arsenidediode laser, emitting a wavelength of 780-810nm.a Ga-Al-As diode laser, at this wavelength, has an affinity towards haemoglobin, melanin and water, and thus does not provide enough penetration depth to affect the alveolar bone and other periodontal tissues. Human PDL shows a marked elevation in $PgE_2$and IL-1β production in response to mechanical stretching. It was seen that laser irradiation inhibited this increase in theproduction of $PgE_2$and IL-1β and helped in therapeutic relief of pain.[5]

III. Biological Mechanism:-

Different biological mechanisms have been explained for the effect of LLLT on stimulating alveolar bone remodeling and thus the rate of tooth movement. Kawasaki and shimizu[6]were the first to propose that LLLT was able to accelerate orthodontic movement by increasing the amount of bone formation and rate of cellular proliferation in the tension side and the number of osteoclasts in the compression side.

Fujita et al.[7] and Aihara et al.[8] demonstrated that LLLT enhanced differentiation and activation of osteoclasts through induction of Receptor activator of nuclear factor kappa b (RANK) and its ligand (RANKL), which is considered as the key osteoclastogenic cytokine. Others reported a relationship between LLLT and expression of macrophage colony-stimulating factor (M-CSF) and its receptor, a cytokine which facilitates proliferation, survival and differentiation of osteoclast progenitors. Martinassoet al.[9] said that LLLT stimulates cell proliferation in human osteoblast-like cells and importantly increases the expression of proteins essential for bone formation.

According to Karu et al.[10], the mitochondrial cytochromes absorb the photon energy, leading to an increase in ATP synthesis and improvement of the potential activity of the cells. Because osteoclasts are multinuclear cells with high-activity mitochondria, they are readily affected by low-level laser irradiation. Furthermore, Hentunen et al.[11] reported osteoclast formation for bone remodelling process is light-dose dependent. Similarly, Zaidi et al.[12] observed that both osteoblasts and osteoclasts have hormonal interaction and so the stimulation of orthodontic tooth movement by LLLT is conceivable, as it consists of concurrent bone resorption and formation.

IV. Different Methods:-

The differences in the method of tooth movement measurement and the use of human versus animal samples were also variable that can affect the treatment results. Luger et al.[13] used doses of about 64 j/cm^2 for enhancing bone mechanic properties in rats, as they believed that the scattering diminishes the energy level of the laser to 3% - 6% of its original intensity.

Kawasaki and shimizu[6]in rats showed that, in their laser irradiation group, the amount of tooth movement was 30% more than that of a non-irradiated group. The laser parameters of Kawasaki and Shimizu[6]were 830 nm, 100 mw, 0.6 mm diameter, 35.3 w/cm^2, with an energy density of around 6000 j/cm^2 from calculation. The energy density was very much higher than it should before the stimulatory effects according to previous knowledge. The results from previous papers of Bradley and Groth[14](820 nm, 25 j/cm^2, rabbits) and takeda[15](904 nm, 20 j/cm^2, rats) had indicated significant bio-stimulatory effects on bone metabolism around this dosage whereas higher dosages presented bio-inhibitory effects, and lower dosages showed non-significant result.

Fig 1: Low-Level Laser Therapy (LLLT) In Orthodontics

Goulart et al.[16] indicated that LLLT (780 nm, 70 mw, area 0.04 cm^2, single spot irradiation) caused a stimulatory effect on orthodontic movement in dogs if the energy density of 5.25 j/cm^2 was employed, whereas the 35 j/cm^2 dosage from the same laser retarded tooth movement when compared to the control side.Yamagishi et al.[17] claimed that only 50% of the light of a diode laser could reach 1 mm depth in bovine mandibular cortical bone. Similarly, Esnouf et al.[18] reported a significant reduction in intensity in the first mm of penetration.

Cruz et al.[19] applied 5 j/cm^2 dosages on each of the 10 points around the canine teeth and found significant acceleration of tooth movement in human subjects. Youssef et al.[20] applied the dose of 8 j/cm^2 distributed over 8 points around the canine tooth and believed that this distribution of energy provided a more adequate result compared to the studies that used a single-point laser application.

Putting together all these previous clinical studies, Ga-Al-As diode laser emitting a wavelength of 780-810 nm with a continuous wave of 5–20 j/cm^2, 2.0-8.0 j when applied around the gingival surface of a tooth, has shown to accelerate the velocity of orthodontic tooth movement. However, the optimum dose required to facilitate tooth movement appeared to be different in human subjects compared to animal subjects.[21]

V. Conclusion:-

The science of cellular and molecular biology is essential to detect what actually happens in the human body, related to the stimulatory dose or the inhibitory dose of LLLT at the surface level. Broader clinical implications of laser in orthodontics would require understanding the characteristics and the limitations of the bio-stimulatory effect of LLLT in addition to the control of tooth movement.

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