# EFFECTS OF LOW LEVEL LASER THERAPY ON THE GINGIVAL AND PERIODONTAL TISSUES IN ORTHODONTIC PATIENTS

**By**

**KISHORE KUMAR**

**Thesis submitted in fulfilment of the requirements**

**for the degree of**

**Master of Science**

**July 2017**

## ACKNOWLEDGEMENTS

I wish to express my deepest gratitude to my supervisor, **Dr Mohammad Khursheed Alam** for his excellent supervision and providing me with such an interesting project to develop my analytical skills. I am also indebted to him for his helpful discussions and constructive criticism.

Besides, my healthiest and greatest appreciation to my co-supervisor **Professor Dr Adam Husein** and also I would like to express my gratitude to the staff of School of Dental Sciences, and Universiti Sains Malaysia for their outstanding guidance and encouragement throughout my study research. Not forgetting my colleagues and every single person that have contributed to this thesis directly or indirectly.

Finally, I would like to acknowledge my dearest family for their many sacrifices and hardships in bringing me up to this world. I am very fortunate to have all of them. I do not have enough words to say how grateful I am to you all.

**TABLE OF CONTENTS**

Page

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF ABBRIVIATION

| | |
|---|---|
| **ANOVA** | Analysis Of Bifactorial Variance |
| **Ar** | Argon |
| **ATP** | Adenosine Tri-Phosphate |
| **BOP** | Bleeding On Probing |
| **CI** | Confidence Interval |
| **cm** | Centi Meter |
| **$CO_2$** | Carbon Dioxide |
| **Er,Cr:YSGG** | Erbium, Chromium: Yttrium Selenium- Gallium Garnet |
| **Er:YAG** | Erbium: Yttrium Aluminum- Garnet |
| **GaAlAs** | Aluminium Gallium Arsenide |
| **GaAS** | Gallium Arsenide |
| **GI** | Gingival Index |
| **HeNe** | Helium–Neon |
| **Ho:YAG** | Holmium :Yttrium Aluminum-Garnet |
| **HREC** | Human Research And Ethics Committee |
| **ICC** | Intra class corelation |
| **IEC** | International Electro Technical Commission |
| **IL-1 β** | Interleukin-1β |
| **IL-6** | Interleukin-6 |
| **IL-8** | Interleukin-8 |
| **InGaAlP** | Aluminium Gallium Indium Phosphide |
| **J** | Joule |
| **LLLT** | Low Level Laser Therapy |
| **m** | Meter |
| **Nd: YAG** | Neodymium :Yttrium Aluminum-Garnet |
| **NiTi** | Nickel-Titanium |
| **OHI** | Oral Hygiene Instructions |

| | |
|---|---|
| **PAD** | Photo-Activated Disinfection |
| **PD** | Probing Depth |
| **PI** | Plaque Index |
| **RSD** | Root Surface Debridement |
| **SD** | Standard Deviation |
| **TBO** | Toluidine Blue O |
| **TGF** | Tumour Growth Factor |
| **TMJ** | Temporo Mandibular Joint |
| **USM** | Universiti Sains Malaysia |

# KESAN TAHAP RENDAH LASER TERAPI TERHADAP GINGIVAL DAN PERIODONTAL TISU DALAM ORTHODONTIK PESAKIT


## ABSTRAK

Tujuan ini berpecah-mulut, eksperimen, percubaan klinikal rawak adalah untuk mengkaji kesan peringkat rendah laser terapi (LLLT) di indeks periodontal sebagai tambahan rawatan teraruh ortodontik gingivitis dan periodontitis dalam fasa awal rawatan ortodontik. Kajian ini telah dijalankan di kalangan empat puluh pesakit yang telah dijadualkan untuk rawatan ortodontik tetap. Selepas pemeriksaan klinikal, semua gigi itu dikecilkan. Parameter klinikal, indeks plak (PI), indeks gingival (GI), pendarahan pada menyelesaikan sesuatu (BOP) dan menyelesaikan sesuatu kedalaman (PD) telah meassuerd dan LLLT telah digunakan pada setiap lawatan iaitu 0, 1, 2, 3, 4, 5 dan 6 bulan di sebelah setiap rahang. Sisi lain rahang dianggap sebagai kawalan. Sisi ujian telah dirawat dengan laser tahap rendah yang mempunyai panjang gelombang 940 nm. PI, GI, BOP dan PD untuk penyelidikan itu direkodkan pada 0 (T1), pertama (T2), ketiga (T3) dan keenam (T4) lawatan. ukuran berulang ANOVA menunjukkan terdapat statistik yang signifikan antara kumpulan dan perbezaan kumpulan intra (<0.05) di mana GI, BOP dan PD skor umumnya meningkat sepanjang tempoh penilaian dalam kedua-dua kumpulan. Markah meningkat lebih dalam kumpulan kawalan. Selain itu, perbandingan dari segi pasangan berdasarkan t ujian Paired menunjukkan bahawa, tidak ada perbezaan yang signifikan di peringkat T1 penilaian daripada GI dan BOP berbanding antara LLLT dan kumpulan kawalan. Walau bagaimanapun, kedua-dua kumpulan menunjukkan perbezaan yang signifikan di T2, T3 dan T4 peringkat penilaian GI dan BOP. Selain itu, perbandingan dari segi pasangan berdasarkan t ujian Paired menunjukkan bahawa, tidak ada perbezaan ketara

dalam T1 dan T3 peringkat penilaian PD apabila dibandingkan antara LLLT dan kumpulan kawalan. Walau bagaimanapun, kedua-dua kumpulan menunjukkan perbezaan yang signifikan di T2 dan T4 peringkat penilaian PD. rawatan tambahan dengan LLLT dikurangkan rawatan teraruh gingivitis dan periodontitis ortodontik.

**EFFECTS OF LOW LEVEL LASER THERAPY ON THE GINGIVAL AND PERIODONTAL TISSUES IN ORTHODONTIC PATIENTS**

## ABSTRACT

The aim of this split-mouth, experimental, randomized clinical trial was to study the effects of low-level lasers therapy (LLLT) on periodontal indices as an adjunct of orthodontic treatment induced gingivitis and periodontitis in initial phase of orthodontic treatment. The study was conducted among forty patients who were scheduled for fixed orthodontic treatment. After clinical examination, all teeth were scaled. The clinical parameters, plaque index (PI), gingival index (GI), bleeding on probing (BOP) and probing depths (PD) were measured and LLLT was applied at every visit i.e. 0, 1, 2, 3, 4, 5 and 6 months on one side of each jaw. The other side of the jaw was considered as control. The test side was treated with low-level lasers having wavelengths of 940 nm. PI, GI, BOP and PD for the research was recorded at 0 (T1), first (T2), third (T3) and sixth (T4) visit. Repeated measure ANOVA showed that there was statistically significant inter group and intra group differences (<0.05) where GI, BOP and PD scores generally increased along the evaluation period in both groups. The scores increased more in the control group. Moreover, pairwise comparisons based on the Paired t test showed that, there was no significant difference in T1 stage of evaluation of the GI and BOP when compared between LLLT and control group. However, both groups were showed significant differences in T2, T3 and T4 stage of evaluation of the GI and BOP. Moreover, pairwise comparisons based on the Paired t test showed that, there was no significant difference in T1 and T3 stages of evaluation of the PD when compared between LLLT and control group. However,

both groups were showed significant differences in T2 and T4 stage of evaluation of the PD. Additional treatment with LLLT reduced the orthodontic treatment induced gingivitis and periodontitis.

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

The decision to begin the orthodontic treatment with fixed appliances should be made after evaluation of risks and benefits to the patients. Orthodontic treatment improves facial aesthetics, speech, mastication and encourages oral and general health that in its turn improves self-confidence of individuals which gives better quality of life (Hamdan, 2005).

Orthodontic treatment objectives can be achieved through the movement of teeth with the application of an external physical force. Typically it takes around 2 to 3 years to finish an orthodontic treatment however long duration of treatment is also associated with some risks and complications (Atack *et al.*, 1996; Ellis and Benson, 2002; Fink and Smith, 1992).

## 1.2 Risks and complications associated with orthodontic treatment

Graber et al., (2005) has classified the risks and complications associated with orthodontic treatment in the following ways

### 1.2.1 According to site

a) Local effects e.g. enamel decalcification and discolorations, external root resorption and gingivitis
b) Systemic effects e.g. allergic reactions to latex and nickel.

### 1.2.2 According to the severity of the condition:

a) Mild e.g. reversible gingivitis
b) Moderate irreversible e.g. enamel fracture during debonding
c) Severe irreversible e.g. decalcifications, caries, and root resorption.

### 1.2.3 Based on role of orthodontist in the adverse effect's occurrence:

a) Standard procedures with integral complications e.g. enamel changes with acid etching during bonding with resins
b) Risks related to the patient's individual susceptibility e.g. allergic reaction or root resorption not disclosed during initial assessment; demineralization is associated with unidentified metabolic disease
c) Conditions that result due to negligence or improper monitoring by operator e.g. decalcifications or severe root resorption
d) Errors by operator and subjects e.g. enamel fracture due to inappropriate debonding technique; poor oral hygiene leads to loss of periodontal attachment (Graber *et al.*, 2005).

Periodontal problems were stated to be one of the most acquainted adverse effects associated with fixed orthodontics (Dannan, 2010). Periodontal complications include

gingivitis, gum recessions, alveolar bone loss, mobility and root resorption (Talic, 2011). These complications can be minimized with meticulous maintenance of oral hygiene. However, many of the patients are failing to follow the oral hygiene instructions (OHI) properly, which sometimes results in irreversible damage to the periodontal health (Morrier, 2014).

During fixed orthodontic treatment the global morbidity of gingivitis reported as 56.8% and 34.4% in adolescent and adult group, respectively (Liu *et al.*, 2013). Thus, researchers are always looking for some non-invasive and reliable techniques to minimize the possibility of occurrence of orthodontic induced gingivitis and periodontitis. Recent studies show that low level laser therapy (LLLT) is effective as an adjunct with routine oral hygiene scaling, root planning to prevent gingivitis and moderate to chronic periodontitis (Qadri *et al.*, 2007; Qadri *et al.*, 2005).

### 1.3 Statement of problem

LLLT has been widely used to reduce the gingivitis and periodontitis (Ambrosini *et al.*, 2005; Qadri *et al.*, 2007; Qadri *et al.*, 2005). However, until now the effects of LLLT on orthodontic induced gingivitis and periodontitis have rarely been evaluated. Secondly, in most of the researches the LLLT has been used as an adjunct to basic periodontal therapy to reduce gingival and periodontal problems, the laser was applied on daily basis or the intervals of laser applications were short.

During fixed orthodontic treatment, recalling patients after the period of every 3 or 4 weeks gap is a very common practice worldwide (Jerrold and Naghavi, 2011). Sometimes regular visits become unsuitable for patients because of forgetfulness or

due to time restraint (AlSadhan, 2013). Therefore, the fact is it is not feasible for patients to spare time from their daily busy life to follow the repeated recall appointments. Based on these problems, in current study, we assessed the effects of LLLT on orthodontic induced gingivitis and periodontitis by applying the LLLT on interval of every 4 weeks without disturbing patient's regular orthodontic treatment visits.

## 1.4 Justification of the study

The requirement for fixed orthodontic treatment has been increased in the past few decades; due to the more awareness in general population. However, orthodontic treatment is associated with some complications, particularly gingivitis and periodontitis, which is extremely inconvenient for patients as well as practitioners. Therefore, it is essential to inspect various modalities to overcome these complications for the benefit of patients.

The use of LLLT is not only promising but also a non-invasive technique. This modality is being used in humans for various uses, without reporting any harmful effects. However, most of the lasers are being used in medicine and dentistry are classified as type 4 according to International Electro technical Commission (IEC) which has potential to cause hazards especially to eyes and skin (Nalcaci and Cokakoglu, 2013). Precise use of equipment and protective glasses are compulsory in use of any laser application. Therefore, the modality is also safer to use. The adaptation of LLLT may be helpful and beneficial to control orthodontic induced gingivitis and periodontitis. However, this modality needs to be explored in kin to orthodontic treatment without disturbing patient regular recall visits. Also there is a need to

investigate the benefits of using LLLT as an adjunct with oral hygiene instructions, scaling and sometime deep curettage as required particularly in initial phase of orthodontic treatment.

## 1.5 Novelty of the research

Current research explored the effects of monthly application of LLLT on orthodontic induced gingivitis and periodontitis. The effects of LLLT on orthodontic induced gingivitis and periodontitis never been evaluated in Pakistan. Moreover, the outcomes of the study gave complete knowledge to the practitioners regarding the effects of LLLT on orthodontic induced gingivitis and periodontitis, when used with oral hygiene instructions related with initial phase of orthodontic treatment.

## 1.6 Objectives

### 1.6.1 General

The primary aim of this research was to study the effect of LLLT as an adjunct with oral hygiene instructions, routine scaling and polishing in orthodontic patients to control the possibility of orthodontic treatment induced gingivitis and periodontitis in initial phase of orthodontic treatment.

### 1.6.2 Specific

1. To determine and compare the effect of LLLT on applied side and control side on Plaque Index (PI)
2. To determine and compare the effect of LLLT on applied side and control side on Gingival Index (GI)
3. To determine and compare the effect of LLLT on applied side and control side on the Bleeding on Probing (BOP)
4. To determine and compare the effect of LLLT on applied side and control side on Probing Depth (PD)

## 1.7 Research hypotheses

1. There is significant difference in the effect of LLLT on applied side and control side on Plaque Index (PI).
2. There is significant difference in the effect of LLLT on applied side and control side on Gingival Index (GI).
3. There is significant difference in the effect of LLLT on applied side and control side on the Bleeding on Probing (BOP).
4. There is significant difference in the effect of LLLT on applied side and control side on Probing Depth (PD).

## 1.8 Research questions

1. Is there any difference in Plaque Index (PI) on the lased side and control side?

2. Is there any difference in the Gingival Index (GI) on lased side and control side?
3. Is there any difference in the Bleeding on Probing (BOP) on lased side and control side?
4. Is there any difference in the Probing Depth (PD) on lased side and control side?

# CHAPTER 2

## LITERATURE REVIEW

Besides the beneficial effects, fix orthodontic treatment also have some adverse effects as secondary consequences like in any other dental and medical intervention (Table 2.1). The scientific literature confirms so many different conditions associated with fixed orthodontic treatment (Ellis, 2002). These characteristics should not be neglected though generally most of them an exact cause-effect relation has not been recognized.

Table 2.1 Adverse effects and complications associated with fixed orthodontic treatment.

| | |
|---|---|
| Dental | Crown: crown decalcifications, cavities, tooth abrasion, enamel fractures and breakages, discolorations, wear of prosthetic crown (some times during debonding).<br>Root: root resorption, premature closing of root apex, ankyloses.<br>Pulp: pulp necrosis, ischemia, pulpitis. |
| Periodontal | Gingivitis, periodontitis, gingival hyperplasia, gingival recession, alveolar bone loss, dehiscence, fenestrations, interdental fold, dark triangles. |
| Temporomandibular joint | Condylar resorption, temporomandibular joint dysfunction. |
| Soft tissues | Trauma due to arch wires, and some time interrelated with headgear, mucosal ulcerations. Chemical burns due to etching, thermal injuries sometimes due to overheated burs, stomatitis and lumbering management of dental instruments. |
| Unacceptable treatment ending | Poor morpho-functional, aesthetic or functional finishing result, relapse, failed to finish the treatment because of treatment dropout. |

Following are the most common complications associated with fixed orthodontic treatment.

## 2.1 Orthodontic induced gingivitis

The periodontium is one of the supportive structures of the tooth comprised of gingiva, alveolar bone, the periodontal ligament and the cementum. The gingiva is a soft tissue section of the periodontium, which is normally stable resilient and having the colour of coral pink. Gingivitis is inflammation of the gingiva categorized by swelling and redness of the gingival tissue and is frequently related with bleeding on probing and in progressive cases also associated with the purulent discharge (Mills, 1967).

Orthodontic treatment with fixed appliances is the treatment of choice for malocclusion and associated problems. However, it also carries some possibilities of harming periodontal tissues due to increase in plaque accumulation around appliances. There are alterations in oral environment and changes in the composition of the oral micro flora that leads to change in host physiology thus result in gingival inflammation (Bollen *et al.*, 2008; Lara-Carrillo *et al.*, 2010).

The inflammatory response of gingival tissue can frequently be noticed in patients with fixed orthodontic treatment. There is agreement amongst researchers on the single important causative factor of periodontal disease, which is bacterial plaque (Lara-Carrillo et al., 2010). However, not all organisms present in plaque are equally pathogenic, and plaque may differ significantly in pattern between individuals. Moreover, the accumulation of plaque and its effect are different on different teeth of the same individual. The variations in the plaque quantity and quality also depends on

the location (sub gingival and supra gingival) and how chronic is the presence of plaque (Axelsson *et al.*, 1991; Socransky and Haffajee, 1992).

Additionally, the host response also plays a role on the ultimate consequence of bacterial plaque. More than fifteen different microorganisms comprising *P. gingivalis*, *Actinomycetemcomitans* and *P. intermedius* are linked with periodontitis (Zachrisson, 1996). Occurrence of microbial plaque stated to be the main reason in the initiation, progression of gingivitis towards periodontitis. During orthodontic treatment, periodontal disease is one of the main concerns. The periodontal problems related with orthodontic therapy mostly include gingival recession, hypertrophy, gingivitis, periodontitis, fenestrations, interdental fold and dark triangles bone loss and dehiscence (Ristic *et al.*, 2007).

Periodontal diseases elaborate a number of inflammatory and degenerative processes of the supporting periodontal structures (Newman *et al.*, 2011). The key etiological element of periodontal infection is plaque deposition around gingival margin (Boyd and Baumrind, 1992; Brandtzaeg, 1966). The deposition of plaque can be a source of gingival redness, rise in the stream of gingival cervicular fluid, bleeding, edema, variations in gingival morphology, reduced tissue attachment to the teeth and other signs of clinical inflammation.

It is well established that the patients who undergo orthodontic treatment have a high susceptibility to plaque accumulation on their teeth because of the presence of different orthodontic attachment, bands, brackets, and wires (Boyd and Baumrind, 1992). The components of fixed orthodontic treatment can alter the biological balance of the oral cavity (Krishnan and Davidovitch, 2006). The main aim of the orthodontic treatment

is to achieve the ideal occlusion with stability and function via tooth movement to the desired position which involves the process of the periodontium alteration (Lusterman, 1974; Sadowsky and BeGole, 1981). Fixed orthodontic treatment is a dual action procedure concerning the periodontal tissues, it may be occasionally very extensive in rising the status of periodontal health, and sometimes a damaging process which can be grasped by several kinds of periodontal complications, mainly gingival recession, gingival invaginations, bone dehiscence, and/or the gingival pockets formation (Årtun and Urbye, 1988). Hence, orthodontic treatment can be referred as a dual edge sword.

The periodontics-orthodontic inter relationship is still controversial. Therefore, it is important to highlight oral hygiene guidelines and to sustain high levels of oral hygiene for patients who carry on orthodontic treatment. Since the application of orthodontic force, whether it is continuous (by a fixed appliance) or interrupted (by removable appliance) brings cellular alterations in the periodontal ligament results in tooth movement. Therefore, a healthy periodontium is essential for preserving the integrity of the dentition (Dannan, 2010). The role of the healthy or unhealthy periodontium is often not fully understood or emphasized upon during the course of orthodontic treatment. However, it is essential to realize that healthy periodontal tissue is the foundation for successful orthodontic therapy (Van Schepdael *et al.*, 2013).

The forces applied throughout orthodontic treatment guides the periodontal tissue remodelling. The accurate /application of orthodontic force does not cause periodontal damage; meanwhile uncontrolled orthodontic forces can spark worsening of present periodontal disease. Approximately every patient of fixed orthodontic treatment develops some degree of gingival infection at some stage during treatment (Atack *et al.*, 1996).

Gingival swelling and redness are normally transitory in nature and settles within one to two months of debonding. Banded appliances causing more gingival complications as compared to contemporary bonded orthodontic appliances (Alstad and Zachrisson, 1979). It has been observed that teenagers emphatically experience more adverse effects of gingivitis than adults during orthodontic treatment (Hamp *et al.*, 1982). It is a prerequisite before any orthodontic intervention to alleviate the periodontal condition. Lasting healthy gingival condition during the fix orthodontic treatment would bring precise treatment result (Boyd *et al.*, 1989). All types of fixed orthodontic treatments induce both positive and adverse local soft-tissue effects in the gingiva.

In the presence of orthodontic brackets and elastics, the effective removal of dental plaque is limited, thereby it increases the risk of gingivitis. It has been noticed that a change in the components and nature of bacteria could be estimated during the orthodontic treatment (Hägg *et al.*, 2004). The balance of oral micro flora usually changes during the Orthodontic treatment. Bacterial retention is escalated which causes increase periodontal indices significantly. Growth of periodontal pathogenic bacteria were witnessed in adolescent patients undertaking fixed orthodontic treatment (Ristic *et al.*, 2007).

Most of the patients, who are undergoing fixed orthodontic treatment observed a minor degree of gingival inflammation which might be transitory in nature and is not directed to gingival attachment loss (Bimstein and Becker, 2001). Periodontal health is affected by many factors like behavioural affects (smoking, oral hygiene, diet) and genetic disorders. Malocclusion might also have a significant effect on periodontal and gingival health as other factors.

Frequently the orthodontists notice a chronic hyperplastic gingivitis following a brief period after the placement of orthodontic fixed brackets. Though it is established that the plaque is the most significant causative factor but the exact aetiology of chronic hyperplastic gingivitis is not yet fully understood. In some individuals the presence of some identified co-factors: genetic and/or environmental interleukin-1 (IL-1), cigarette smoking, diabetes, and leukopenia also contribute in the hyperplastic gingivitis leading to periodontitis (Coppotelli *et al.*, 2014).

## 2.2 Orthodontic Induced Periodontitis

Advancement of the lesion of gingivitis is diagnosed as the periodontitis. Periodontitis might be severe or aggressive in association with systemic diseases (Noack *et al.*, 2001). It may be localized or generalized. Periodontitis is usually chronic in nature and a slowly progressive disease where gingival inflammation may not be appeared. It is typically painless and frequently detected by probing (Pihlstrom, 2001). Periodontitis is sometimes aggressive in nature which is categorized by speedy advancement of disease leading to a severe destruction of the periodontium (Armitage, 2004). As a result of the orthodontic treatment a change in the presentation and nature of bacteria could be anticipated (Hägg *et al.*, 2004). Orthodontic treatment enhances the bacterial retention which disturbs the balance of oral micro flora. Due to these changes the levels of periodontal indices are raised and lead to periodontal disease. Periodontal pathogenic bacteria were witnessed especially in adolescent patients undertaking fixed orthodontic treatment (Ackerman, 2007; Ristic *et al.*, 2007). Increased incidences of periodontal complications were noticed at some stages in particular cases of orthodontic treatment. For example, after space closure and extraction during

orthodontic treatment sometimes induced gingival hyperplasia. Therefore, in those cases the higher frequency of periodontal interdental folds were observed (Preoteasa *et al.*, 2012).

The chances of development of fenestrations and dehiscence were increased in the maxillary expansion cases of orthodontic treatment after moving teeth in the buccal/lingual direction (Preoteasa *et al.*, 2012). It is well known fact that dental plaque provides the platform for the development of pathogenesis of gingivitis and periodontitis. The advancement of periodontal disease depends on the immune and inflammatory response of host microbial biofilms (Alves, 2012; Haffajee and Socransky, 2005). The growth of plaque rises after placing the orthodontic brackets which cause development of gingival hyperplasia and pseudo pockets (Gong *et al.*, 2011; Sallum *et al.*, 2004). This condition alters the sub gingival ecosystem and increases the amount of periodontal pathogens. These influence some virulence factors that accelerate host cells to discharge numerous kinds of inflammatory cytokines such as interleukin-1β (IL-1β), interleukin-6 (IL -6) and interleukin-8, (IL-8) and growth factors such as tumour growth factor (TGF), which moderate the inflammatory reaction in periodontal tissues (Teles *et al.*, 2010).

The presence of fixed orthodontic brackets for prolonged periods might raise sub gingival microbe shift and development of periodontal disease (Diamanti-Kipioti *et al.*, 1987). Some of the periodontal issues are likely to develop at some stage in fixed orthodontic treatment due to presence of orthodontic brackets and bands. Poor compliance by the patient in maintenance of oral hygiene and improper orthodontic components could drive the bacterial plaque into the deeper gingival site and alters the micro flora which contributes to the development of gingivitis into periodontal disease

(Lauritano and Caccianiga). Due to alteration in the oral ecosystem, subsequent formation of pathological conditions has been increased due to uncontrolled colonization of bacteria (Mager *et al.*, 2003; Zarco *et al.*, 2012). The periodontal pockets are believed to be the pathogenic niches in the mouth. Some studies have concluded that pathogens are found more in gingival crevice than the other sites, from where the pathogens can progress to colonize in some other deeper areas (Rudney *et al.*, 2001). The fixed orthodontic treatment has great influence on the microbial penetration in the ecological niches and multiplication in the bacterial amount in the buccal epithelial cells and the gingival crevice (Rudney *et al.*, 2005)

Many studies recommended that inter-dental areas are particularly more periodontally disturbed in patients with fixed orthodontic appliances (Alexander, 1991). During fixed orthodontic treatment, these areas are difficult to keep free from plaque, which leads significantly increases the accumulation of dental plaque and increase in pocket depth (Nunn, 2003). Patients who underwent fixed orthodontic treatment are usually witnessed loose gingival attachments around the teeth and increased bleeding on probing (Zachrisson and Zachrisson, 1972).

## 2.3 Treatment protocol

Patients must be informed about the fixed orthodontic treatment, their responsibilities and possible risk associated with the orthodontic treatment. Proper oral hygiene instruction should be given to the patients in the initial phase of fixed orthodontic treatment (Hănțoiu *et al.*, 2014). Appropriate guidelines and positive reinforcement regarding management of new oral atmosphere and its preservation must be

emphasized. Following are the options to treat orthodontic induced gingivitis and periodontitis.

- Oral hygiene instruction (OHI) given to the patients and removal of all supra and sub gingival plaque and calculus
- Root surface debridement (RSD)
- LLLT should be used as an adjunctive to effective periodontal remedies; it is not a replacement (Parker, 2007).

### 2.3.1 Low level Laser Therapy

Laser therapy is one of the highly appealing equipment in modern dental practice from the time when Theodore Maiman in 1960 discovered the ruby laser. Lasers in dentistry gave rise to a revalution in several fields of treatment in the last four decades of the $20^{th}$ century. Laser has nowadays been converted into an familiar appliance in different field of dentistry for different dental treatments (Elavarasu *et al.*, 2012).

The major applications of laser in dentistry are as follows:

- Photobiostimulation
- Curing of Composite resin restorations
- Detection of dental caries
- Photo-activated disinfection (PAD)
- Laser scanning (restorative dentistry, orthodontics) (Parker, 2007).

### 2.3.2 Photobiostimulation

After the invention of the first laser in the late 1960s, laboratory trials found regenerative healing effects in mice. Mostly in the patients where conventional treatments of open wound are unsuccessful, laser had success rates of 85% (Fisher *et al.*, 1983). The acceptance of LLLT therapies flourished, mainly after the innovation of diode lasers (GaAS 904 nm, GaAlAs 780-890 nm and later, InGaAlP 630-700 nm).

All these lasers have deep penetrative potential in tissue; the core principle behind their action is stimulation of cellular and biochemical (indirect) elements. The usage of these wavelengths focus around research that endorsed the claims of advantages in management of musculo-skeletal, neuro-muscular, cytogenic and trauma-related states as a result of biological special effects known as photobiostimulation (Parker, 2007).

#### 2.3.2.1 Advantages of photobiostimulation effects of LLLT

Photobiostimulation includes the application of visible red to the tissue to accelerate and improve healing and to decrease the pain. Light waves potentially invade several millimetres, these wavelengths accelerate deep cellular function, and this light energy is immersed within living tissue by cellular photoreceptors, e.g. cytochromophores. Cellular mitochondria transforms electromagnetic energy into ATP (adenosine tri-phosphate) (Passarella *et al.*, 1984). Therefore, the stimulated rise in ATP production would intimate an increased in cellular activity e.g. fibroblasts, contributing in tissue healing (Karu, 1987).

Furthermore, the transformation of light energy into heat causes an enhancement in local microcirculation via vasodilation. Following are the stimulatory effects of LLLT:

a. Increased production of macrophages (Dube *et al.*, 2003)
b. Increased production of lymphocytes (Dube *et al.*, 2003)
c. Increased production of fibroblasts (Dube *et al.*, 2003).
d. Increased production of endothelial cells (Stadler *et al.*, 2000)
e. Increased production of keratinocytes (Stadler *et al.*, 2000).
f. Increased cell respiration/ATP synthesis (Choi *et al.*, 2010).
g. Increased the flow of release of growth factors and also other cytokines (Kov *et al.*, 1974).
h. Conversion of fibroblasts into myofibroblasts (Kov *et al.*, 1974).
i. Collagen synthesis (Enwemeka *et al.*, 2004).

Furthermore, there is evidence which verifies the analgesic effects of LLLT, as a result of an enhanced production of endorphins and bradykinins, reduced the c-fibre activity and modified the pain threshold (Laakso *et al.*, 1994). Some other researchers suggest about the therapeutic analgesic effect of LLTT, as a result of the release of serotonin and acetylcholine centrally, and peripherally release of histamine and prostaglandins with the application of LLLT (Riegel, 2012).

### 2.3.3 Doses for Low Level Laser Therapy

The doses of low-level laser light are vital for the beneficial effects of the wave lengths used. This was established on the Arndt Schultz law, described as “minor doses inspire living systems, moderate doses impede, and huge doses destroy” (Ohshiro and

Calderhead, 1988). According to the some research studies, the cellular effects after the application of LLLT are as follows (Al-Watban and Andres, 2000).

1. <.06 J/cm$^2$ – zero bio-activation
2. .12-.24 J/cm$^2$ – bio-stimulation
3. .24-.30 J/cm$^2$ – zero bio-activation
4. .30-.60 J/cm$^2$ – bio-inhibition (release of cellular singlet oxygen)

The volume of laser energy released to a targeted tissue is characterized by energy density, which is measured in J/cm$^2$. In clinical procedure the LLLT become effective as a result of stimulatory mechanism instead of ablative mechanisms which requires the energy density of 2-10 J/cm$^2$, depending on the condition of the target tissue (Bjordal *et al.*, 2008a).

Following are the parameters:

1. Oral epithelium and gingival tissue – 2-3 J/cm$^2$
2. Trans-osseous irradiation (target – peri apical area) – 2-4 J/cm$^2$
3. Extra-oral muscle groups/TMJ – 6-10 J/cm$^2$ (Bjordal *et al.*, 2008b)

Table 2.2 Features of wave lengths of lasers Applied in Clinical Dentistry (Ramesh *et al.*, 2014)

| **Laser type** | **Common Abbreviation** | **Wave length** | **Wave form** | **Delivery Tip** | **Reported Periodontal Applications** |
|---|---|---|---|---|---|
| **Carbon dioxide** | $CO_2$ | 10.6 mm | Gated or Continuous | Hollow waveguide; beam fixated 1 to 2 mm from recipient area | Ablation and incision of soft tissues. curettage of sub gingival tissue |
| **Neodymium :yttrium aluminum-Garnet** | Nd: YAG | 1.064 mm | Pulsed | Variable fiber optic system of variable diameters; contact with recipient area needed for so many procedures | Bacterial eradication curettage of tissues of sub gingival area, ablation and also incision of soft tissue |
| **Holmium :yttrium aluminum-Garnet** | Ho:YAG | 2.1 mm | Pulsed | variable fiber optic system; contact with recipient area needed for so many procedures | Bacterial eradication, incision and ablation of soft tissue, curettage of tissues of sub gingival area. |
| **Erbium: yttrium aluminum-Garnet** | Er:YAG | 2.94 mm | Free-running Pulsed | variable fiber optic system or contact with recipient area needed for so many procedures | Incision of Soft tissue ; curettage of sub gingival area and also of root surfaces; |

| | | | | | |
|---|---|---|---|---|---|
| **Erbium,**<br>**chromium: yttrium selenium-**<br>**gallium garnet** | Er,Cr:YSGG | 2.78 mm | Free-running<br>Pulsed | Sapphire crystal insertions of different diameters; contact with recipient area needed for so many procedures | ablation and incision of soft tissue curettage of sub-gingival area, osteotomy and osteoplasty |
| **Neo dymium: yttrium aluminum-**<br>**Perovskite** | | 1,340 nm | Pulsed | Flexible fiber optic system; surface contact required for most procedures | Bacterial eradication ablation and incision of soft tissues curettage of sub- gingival area |
| **Indium-gallium arsenide-**<br>**phosphide;**<br>**gallium-aluminum arsenide;**<br>**gallium arsenide** | Nd:YAP<br>In GaAsP(diode)<br>GaAlAs (diode)<br>GaAs (diode) | Wave length of<br>Diodes laser can vary from<br>635 towards 650 nm | Gated or<br>Continuous | Variable fiber optic system; contact with recipient area needed for so many procedures | Bacterial eradication ablation and incision of soft tissues curettage of sub- gingival area |
| **Argon** | Ar | 488 to 514 nm | Gated or<br>Continuous | Variable fiber optic system | Ablation and incision of Soft tissue |

Different wavelengths emitted from various types of lasers have been used in clinical dentistry to attain specified effects e.g.

1. Post-trauma situations especially post-extraction socket (Taube *et al.*, 1989)
2. Apthous ulceration (Migliorati *et al.*, 2001):
3. Viral infections: Hand, foot and mouth disease, Herpes simplex and herpes labials. (Parker, 2007)
4. Temporo-mandibular joint dysfunction (Ahrari *et al.*, 2014).
5. Neuropathy: paraesthesia and trigeminal neuralgia (Ahrari *et al.*, 2014).
6. Post-oncology: healing of post-surgery lesions and also mucositis (Wong and Wilder-Smith, 2002).
7. Dentine hypersensitivity (Kimura *et al.*, 2000).

The previous study about the effects of LLLT on periodontal diseases suggest that the application of a low-level laser could significantly minimize the gingivitis and periodontitis. The irradiation parameters and protocols used for LLLT were successful in decreasing the gingivitis and periodontitis (Qadri *et al.*, 2007).

# CHAPTER 3

# MATERIALS AND METHODS

## 3.1 Ethical approval

Ethical approval was obtained from the Human Research and Ethics Committee (HREC), Universiti Sains Malaysia [USM/JEPeM/16090277] and the ethical review committee of the Aga Khan University Hospital of Karachi Pakistan (project number 3601-Sur-ERC-15) (APPENDIX 2 and APPENDIX 3).

## 3.2 Design of study

This was an experimental; randomized controlled trial utilizing LLLT to check the gingival and periodontal condition during initial stage of orthodontic treatment. One side of the jaw was treated with LLLT and another side of the jaw considered as control, therefore this was split mouth clinical trial.

## 3.3 Study population and samples

This research was conducted among Pakistani subjects who were undergoing orthodontic treatment. Research subjects were gathered from Aga Khan Hospital for Women Karimabad A secondary hospital of Aga Khan University Hospital of Karachi Pakistan. The duration of the study was six months in which each patient had regular monthly follow up orthodontic treatment visits. LLLT was applied at every visit i.e. 0, 1, 2, 3, 4, 5 and 6 months on one side of each jaw, while the other half of the arch was

control. The clinical parameters, Plaque index (PI), gingival index (GI), Bleeding on Probing (BOP) and Probing Depth (PD) for the research was recorded at 0, first, third and sixth visit. Data was recorded simultaneously.

## 3.4 Sample frame

The sample frame of patient recruitment for this research consisted of patients who signed consent for this research and fulfilled the inclusion and exclusion criteria. Our sample comprised of 40 pre orthodontic patients, with an age range of 16 to 30 years (APPENDIX 4 and APPENDIX 5).

### 3.4.1 Inclusion criteria

1. Selected patients were Pakistani in origin
2. Age 16 to 30 years
3. Patient with healthy periodontium with no signs of gingival inflammation
4. Patients who were about to get their fixed orthodontic treatment started with the conventionally ligated brackets
5. Patients who signed consent for this research (One of the parents, either father and/or mother signed written assent for the minor subjects).

### 3.4.2 Exclusion criteria

1. Patients on medications which alter the gingival health e.g. Phenytoin (Dilantin), Cyclosporine A (Sandimmun), Nifedipine (Adalat), Corticosteroids, contraceptive pills