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Treatment of Myogenic origin TMJ disorders using 940 nm diode laser and pharmacotherapy

(Comparative study)

A Thesis Submitted to the Institute of Laser for Postgraduate Studies, University of Baghdad in Partial Fulfilment of the Requirements for the Degree of Master of Science in Laser / Dentistry

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بسم الله الرحمن الرحيم

اللَّهُ نُورُ السَّمَاوَاتِ وَالْأَرْضِ مَثَلُ نُورِهِ كَمِشْكَاةٍ فِيهَا مِصْبَاحٌ الْمِصْبَاحُ فِي زُجَاجَةٍ الزُّجَاجَةُ كَأَنَّهَا كَوْكَبٌ دُرِّيٌّ يُوقَدُ مِنْ شَجَرَةٍ مُبَارَكَةٍ زَيْتُونَةٍ لَا شَرْقِيَّةٍ وَلَا غَرْبِيَّةٍ يَكَادُ زَيْتُهَا يُضِيءُ وَلَوْ لَمْ تَمْسَسْهُ نَارٌ نُورٌ عَلَى نُورٍ يَهْدِي اللَّهُ لِنُورِهِ مَنْ يَشَاءُ وَيَضْرِبُ اللَّهُ الْأَمْثَالَ لِلنَّاسِ وَاللَّهُ بِكُلِّ شَيْءٍ عَلِيمٌ

صدق الله العظيم { سورة النور اية ٣٥ }

Certification

I certify that this thesis was prepared under my supervision at the Institute of Laser for Postgraduate Studies, University of Baghdad, as a partial fulfillment of the requirement for the degree of “Master of Science of Laser/Dentistry".

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Dedication

To the soul of my beloved Father

Adnan (mercy upon him)

To my family,

Thanks for your patience, love, support, and devotion

Without you, this effort would have been very difficult.

May Allah help me to give you happiness

Anes

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Anes

2017

Abstract

Introduction: Myogenic origin TMJ disorders are common disorder with patients visiting dental clinics. The main etiologic factors that lead to TMDs are the malocclusion, mechanical trauma, emotional and psychological stress, and stroke parafunctional activity. Different modes of treatments were suggested to manage these disorders, commonly pharmacotherapy, physical therapy, psychological therapy, acupuncture, relaxation splints, Botox and recently, laser therapy. Dental lasers are raising the temperature in the target by photothermal and photochemical interactions, which is within the influence of safety for the tissues and helps to relieve muscle spasm and enable it to function normally.

Objective: Evaluation the treatment of myogenic origin TMJ disorders using Diode laser (940 nm) and pharmacotherapy.

Materials & Method: Forty patients who diagnosed with the pain in TMJ region and mouth opening limitation have divided into two groups. One group received Indomethacin, Orphenadrine citrate and paracetamol, and Diazepam for 2 weeks. The other group received laser therapy (diode 940 nm CW) six sessions in two weeks. Pain intensity has measured by visual analogue scale (VAS) and maximum painless mouth opening. Estimation of results have done pre- and post-treatment, and followed for three months. Data had collected and analyzed with SPSS software. A $P < 0.05$ was considered significant and $P < 0.005$ was considered highly significant.

Results: There were significant difference of laser group and pharmacotherapy group ($p < 0.05$) before and after treatment. The group that it's patient were treated with laser showed better maximum mouth opening, and more decrease in pain levels than the patients treated with pharmacotherapy, and specifically, After 1st day of treatment session, with recurring signs and symptoms of the disorder to some patients in the pharmacotherapy group after three months.

Conclusion: Treatment with laser lead to significant improvement in mouth opening and pain intensity in patients with myogenic origin TMJ disorders. The diode laser showed better results in shorter time, safer and more effective to use than medications.

List of Abbreviations

Term	***Abbreviations***
Adenosine triphosphate Aluminum- Gallium-arsenide	AlGaAs
Adenosine triphosphate	ATP
Carbon dioxide	CO2
Ccognitive Behavioral Therapy	CBT
Continuous wave	CW
Deep Hand Piece	DHP
ELECTRO MAGNETIC SPECTRUM	EMS
Erbium-chromium: Yttrium, Scandium, Gallium and Garnet	Er,Cr:YSGG
Erbium-doped: Yttrium, Aluminum, and Garnet	Er:YAG
Gallium-arsenide	GaAs
Gamma-aminobutyric acid	GABAA
Helium Neon	He-Ne
Hertz (unit of frequency)	Hz
InfraRed	IR
Joule per square centimeter (unit of energy density)	J/cm²
Potassium titanyl phosphate	KTP
Laser Doppler flowmetry	LDF
Low level laser therapy	LLLT
Mouth opening	MO
Maximum mouth opening	MMO
Nanometer (= 10 -9 m)	Nm
Neodymium doped Yttrium –Aluminum Garnet	Nd:YAG
Nitric Oxide	NO
Nonsteroidal anti-inflammatory drugs	NSAIDs
Ortho Pantomo Gram	OPG
Photo-Activated Detergents	PAD
Photodynamic therapy	PDT
Photon Induced Photoacoustic Streaming	PIPS
Research diagnostic criteria of TMD	RDC/TMD
Reactive Oxygen Species	ROS
Standard Deviation	S.D
Standard Error	S.E
Temporomandibular disorder	TMD
Temporomandibular Joint	TMJ
Ultra violet	UV

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CHAPTER. ONE: Introduction and basic concepts

1.1 Introduction and background

Temporomandibular disorder is a clinical term involving the symptoms refer to illness of (TMJ), and related muscular and bony structures [1].

The patient with a TMD generally is subjected clinical examination, history, and use of other methods such as a questionnaire. None the less, clinical examination is the main part of TMD diagnosis. It consists of measurement of mandibular movements with a digital calliper, palpation of masticatory muscles and Temporomandibular Joint; however, certain observations, which related to tenderness in the musculoskeletal and nervous parts, should take a side of the study [2].

TMDs are disorders characterized by functional abnormalities and/or musculoskeletal pain at the masticatory muscles. Pain can be mild, moderate, or severe, also constant or intermittent, intensive during mastication, and it is frequently associated with jaw restricted movements result mouth Opening limitation [3].

The prevalence of TMDs has different from one country to another and has been documented to be in the range of 6 to 68% among populations over the world. Epidemiological studies of patients visit the dental clinics show that (TMJ) masticatory muscle tenderness (15%); maximum mouth opening < 40 mm (9%); and the pain during mouth closure (1%) [4].

TMD are the most common disorders of which patients seek treatment during a visit to the dental clinic. The main etiologic factors that lead to TMDs are the malocclusion, trauma, emotional and psychological stress, and stroke parafunctional activity [5].

Different modes of treatments were suggested to manage these disorders; mainly these are pharmacotherapy, physical therapy, psychological therapy, acupuncture, relaxation splints, Botox and recently, laser therapy [6].

The laser therapy is a mode of the treatment for TMJ disorders. Low intensity laser has capable of relieving pain due to the laser's analgesic effect, which allows the patient to resume functions and providing comfort [7, 8].

1.2 Anatomy of TMJ region

TMJ is a joint in the maxillofacial region, and paired articulation connects the skull by the temporal bone at a higher part and the mandible at lower part. The bilateral joints are forming by means of the mandible forming a bicondylar articulation, and for that reason they cannot move freely. Each temporomandibular joint is referred as a "ginglymoarthrodial" joint since this craniomandibualr connection is capable of rotary (ginglymoid) and translatory (arthrodial) movements through jaw function involving mouth opening and closure, speech ,and mastication ,as shown in Figure 1-1 [9].

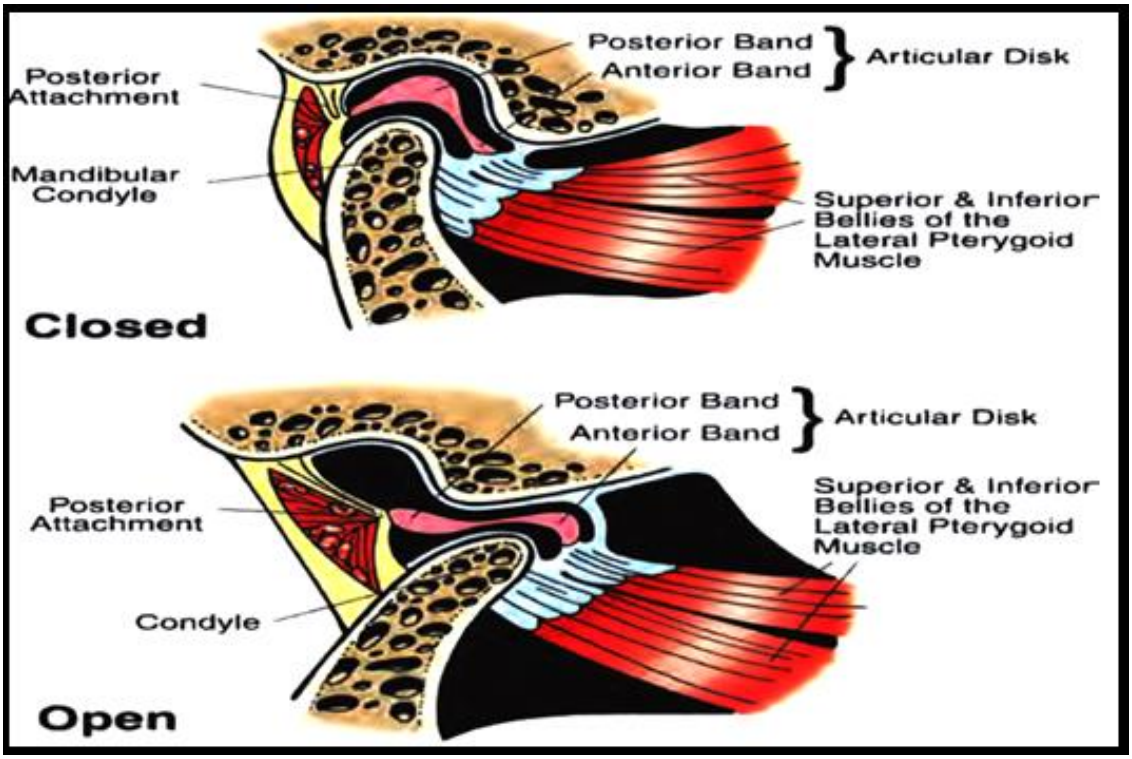


Figure 1-1: The temporomandibular Joint [9].

1.2.1 Muscular components of TMJ region

There are two types of masticatory muscles according to their role in mastication as primary muscles and accessory, Figure 1-2 summarizes the primary mastication muscles that included in this study.

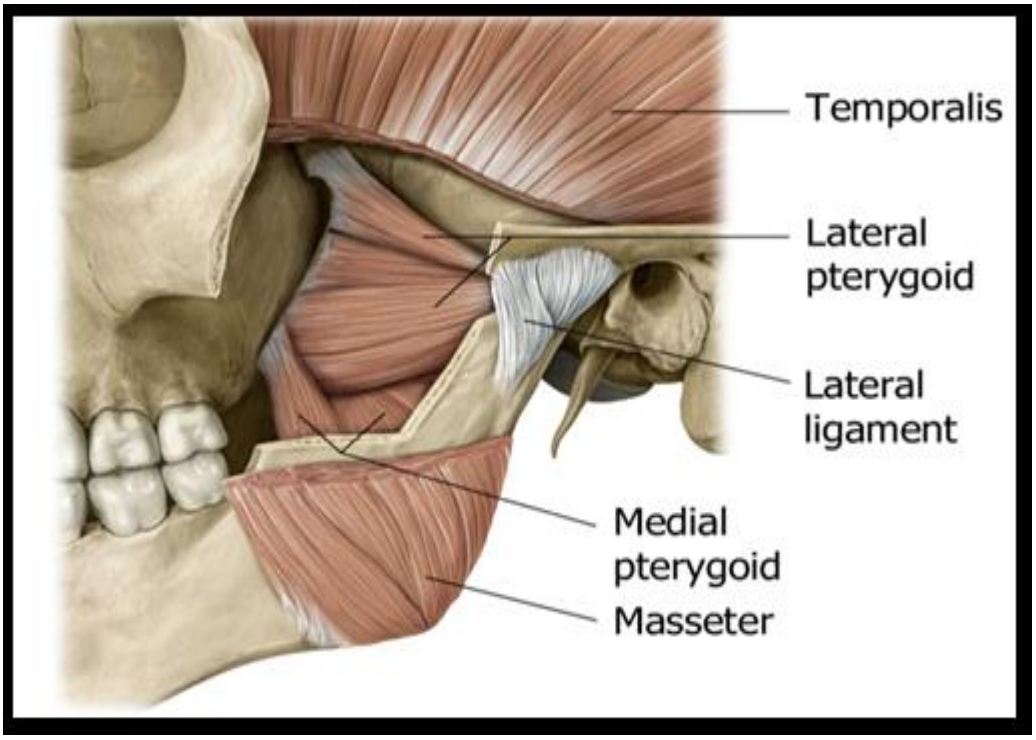


Figure 1-2: Primary masticatory muscles [9]

i. Temporal muscle

This muscle originates from lateral face of the temporal fossa. This muscle is divided into three distinct areas according to fiber direction and function. Due to the angulation of muscle fibers of temporalis, the temporal muscle control the closing action. The innervation by Cranial nerve 5 (trigeminal nerve), division III [10].

Clinically: If the lower jaw move to incorrect position, aggravation will happen and will contract extremely, the trigger points will be formed. Anterior and posterior temporal arteries form the blood supply [10].

ii. Masseter Muscle

Rhomboidal muscle is consisted of fibers direct downward and slightly backward, and fibers direct downward and foreword. They attach to the surface of the ramus on the mandible and the coronoid process. The masseter has the power necessary to chewing [11]. Innervation of this muscle by Cranial nerve 5 (trigeminal nerve), division III. If this muscle contracts intensively, forming painful area in patients with bruxing or clenching. Alteration of masseter due to skeletal closed bite, dental overbite is deep, inadequate vertical dimension, or short part of lower face height, which causes the muscles to be shorten. The blood supply from Masseteric branch of maxillary artery [11].

iii. Lateral Pterygoid muscle

This muscle has superior and inferior head origins; Insertion of these two heads is inferior portion from articular disc, and superior part from neck of the condyle. The inferior lateral pterygoid operates to open the mouth, when the superior is inactive, becoming active when coupling with the elevators. The superior lateral pterygoid function during the strong stroke during the teeth holding.

Innervation of this muscle through Cranial nerve 5 (trigeminal nerve), division III. When the patient has a deep overbite, the lateral pterygoids will be overloaded and form the trigger points. Vascularization of lateral pterygoid muscle by branches of masseteric artery [12, 13].

iv. Medial Pterygoid muscle

Origination of this rhomboidal muscle from medial surface of the lateral pterygoid plate, and maxillary tuberosity to posterior and lower portion of ramus, and angle of mandible. The main function is Protracts and elevates the mandible. Contribution in the rotary movements of the mandible. Clinically: medial pterygoid sensitive in patients with TMJ dysfunction, so need to palpate smoothly. Blood supply from branch of masseteric artery [13].

Each muscle fiber itself contains a massive number of cylindrical organelles are called Myofibrils and forming bundles of Actin and Myosin proteins which control the length of fibers and they have main role in muscle contraction. The network of tubules and channels are framing the Myofibril in which Calcium is stored that it has role in muscle contraction is a called the Sarcoplasmic Reticulum. Throughout the Myofibril, Transverse tubules pass inwards which nerve impulses is moving [14, 15]. The main components of skeletal muscles are drawn in Figure 1-3.

Muscle cells produce ATP molecules which are fuel for the action of the myosin heads. Muscles have a reservoir of energy is called creatine phosphate from ATP and regenerate ATP at need plus creatine kinase. Muscles keep a glucose as glycogen. Glycogen has directed to glucose to generate energy required for actions [16].

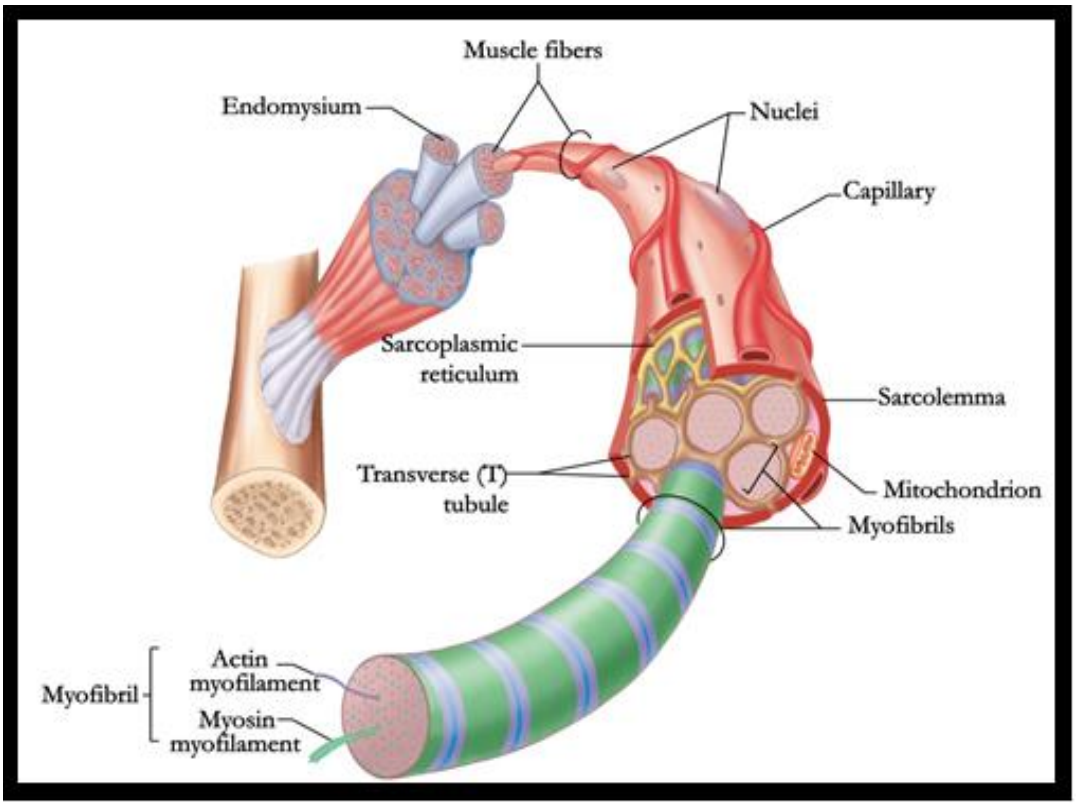


Figure 1-3: The components of the skeletal muscle [17]

1.2.2 Parotid region

Parotid gland, preauricular lymph nodes and facial nerve occupies parotid area. Facial nerve reaches this gland from the stylomastoid foramen. Stinson's Duct emerges from the anterior border of the parotid gland and it opens into the vestibule of the mouth close to upper 2nd molar tooth. The external carotid even superficial temporal arteries represent the arterial supply of parotid gland. The venous drainage of parotid gland takes place into retromandibular and external jugular veins. In front of tragus of ear [18, 19].

1.2.3 Embryonic Development of the Temporomandibular Joint

TMJ development occurs mainly between the 7th and 20th week of intrauterine life. There are three stages in TMJ development [20]:

I. Blastemic stage (7th-8th week; growth of the condyles, articular fossa, articular disk and capsule).
II. Cavitation (9th-11th week; starting of lower joint space formation and condylar chondrogenesis, and maturation stage (after the 12th week).
III. The maturation stage (after week 12 of development).

1.3 Diagnosis of TMDs

Clinical signs occurring simultaneously or independently characterize myogenic origin TMJ disorders:

- The temporomandibular joint pain
- Difficulty opening and/or closing your mouth
- Pain of the masticatory muscles (by mastication or palpation)
- Anomalies in mandibular movements (shifting unilaterally)
- Signs and symptoms are associated with orofacial pain and/ or problems.
- Earache or headache.

For the diagnosis of TMD, the patient must report subjective symptoms of pain and/or dysfunction, and clinical signs of TMD must be detected at clinical examination:

1. IPAP (Inspection, palpation, percussion, and auscultation).
2. Investigation either

   A: conventional (X-ray, CT, MRI).

   B: Laboratory investigation.

Myogenic disorder of masticatory muscle associated with painful muscles of mastication, and the myofascial bands look like be taught and concentrated trigger points and may progress to tendonitis. The most common etiology is parafunctional behavior that hurts the muscles of mastication, and cause local irritation and inflammation [23].

1.3.1 Etiology

The multifactorial etiology of TMD's are [24]:

I. **Biologic factors** may be a general, or systemic, affecting the muscular and articular aspects of TMD ,and they are divided into :-

A. The primary factors are :

(i) Malocclusion (unilateral missing teeth, and posterior open bite).

(ii) Myogenous fatigue because muscle over activity (due to mouth opening for long period, bruxism and chewing gum).

(iii) Inflammation or infection in one or more parts of TM region.

B. The secondary factors (conditions that may mimics the TMD) [24,25] :

1. Salivary stone.
2. Dental conditions (cracked tooth ,dental caries, and dry socket)
3. Migraine headache.
4. Sinusitis.

II. **Neuropathic conditions** (Trigeminal neuralgia and Post herpetic neuralgia).

III. **Psychosocial and emotional**: psychological influences of cultural environment lead to faulty masticatory behavior then malfunction and pain. Young adults aged have a multifactorial etiology, including local factors, and psychological.

1.3.2 Theories of etiological factors of TMD's

A. Mechanical displacement theory

This theory hypothesized on missing molar support or functional occlusal prematurity caused a direct eccentric position of the condyle in the fossa leading to pain, dysfunction then led directly to an inadequate and adverse muscle activity [26].

B. Neuromuscular theory

The role of occlusal interferences is present to provoke parafunction such as clenching and grinding that lead to muscle spasm and muscle hyperactivity and other features of the TMDs that was approved by cross-sectional [27].

C. Muscular theory

This theory considers that primary etiological factor of the TMDs is the masticatory muscles themselves which means the over stimulation and lack of adequate muscle exercise results in muscle fatigue, tension and spasm [28].

D. Psychophysiological theory

The effect of parafunctional activities (tooth clenching, grinding, nail biting, gum chewing) causes abnormal mechanical stress in the TMJ, since increasing of stress may be responsible for disk displacement and with internal derangement or osteoarthritis [29].

E. Psychological theory

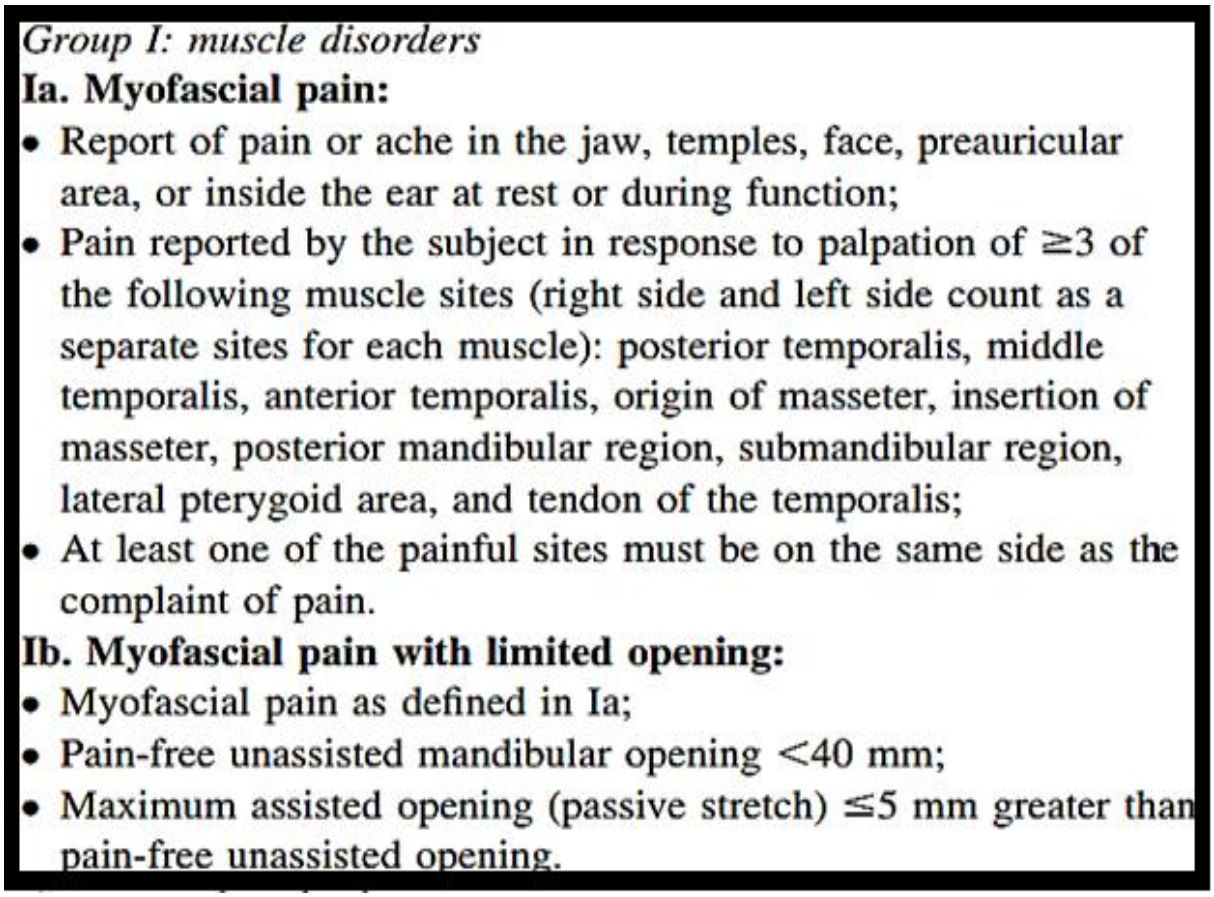
This theory summarize that muscle hyperactivity is a result from emotional and psychological disturbances (stress, anxiety, depression) and stated that muscle hyperactivity is central to a pathologic process and found that emotional stress can influence TMDs by reducing individual's physiological tolerance [30].

1.3.3 TMD Classification

TMD are classified as Intra-articular: disk displacement through the condyle–disk relationship, It is the most known intra-articular cause of TMD, and Extra-articular (Involving the surrounding musculature) [31].

1.3.4 RDC/TMD

Dworkin and Le Resche in 1992 introduce RDC/TMD) to facilitate the diagnostic research about TMD'S over the world [35]. The RDC/TMD Provide solid assessment and diagnostic methods for the most common TMDs. The advantage of strict criteria is more specificity that is non-cases have diagnosed as inclusion cases.



Group I: muscle disorders

Ia. Myofascial pain:

- Report of pain or ache in the jaw, temples, face, preauricular area, or inside the ear at rest or during function;
- Pain reported by the subject in response to palpation of ≥3 of the following muscle sites (right side and left side count as a separate sites for each muscle): posterior temporalis, middle temporalis, anterior temporalis, origin of masseter, insertion of masseter, posterior mandibular region, submandibular region, lateral pterygoid area, and tendon of the temporalis;
- At least one of the painful sites must be on the same side as the complaint of pain.

Ib. Myofascial pain with limited opening:

- Myofascial pain as defined in Ia;
- Pain-free unassisted mandibular opening <40 mm;
- Maximum assisted opening (passive stretch) ≤5 mm greater than pain-free unassisted opening.

Figure 1-4 A: Research diagnostic criteria of TMD Group I [32]

Group II: disc displacements

IIa. Disc displacement with reduction:

- Reciprocal clicking in TMJ (click on both vertical opening and closing that occurs at point ≥5 mm greater interincisal distance on opening than closing and is eliminated on protrusive opening), reproducible on 2 out of 3 consecutive trials; or
- Clicking in TMJ on both vertical range of motion (either opening or closing), reproducible on 2 out of 3 consecutive trials, and click during lateral excursion or protrusion, reproducible on 2 out of 3 consecutive trials.

IIb. Disc displacement without reduction with limited opening:

- History of significant limitation in opening;
- Maximum unassisted opening ≤35 mm;
- Passive stretch increases opening by ≤4 mm over maximum unassisted opening;
- Contralateral excursion <7 mm and/or uncorrected deviation to ipsilateral side on opening;
- Absence of joint sound or presence of joint sounds not meeting criteria for disc displacement with reduction.

IIc. Disc displacement without reduction, without limited opening:

- History of significant limitation of mandibular opening;
- Maximum unassisted opening >35 mm;
- Passive stretch increases opening by ≥5 mm over maximum unassisted opening;
- Contralateral excursion ≥7 mm;
- Presence of joint sounds not meeting criteria for disc displacement with reduction;

Figure 1-4 B: Research diagnostic criteria of TMD Group II [32]

1.3.5 Myofascial Pain

(MPS) is a condition with the sensory, motor, and autonomic symptoms. Mostly this type of pain syndrome refers to be myalgic, that recognized by the presence of a small, painful, focal areas of muscle which called trigger points (Figure 1-5).

Each points provide evidence of the muscular dysfunction in orofacial region, also tender region in skeletal muscle, since these bands are a group of contracted fibers; they are palpable [33].

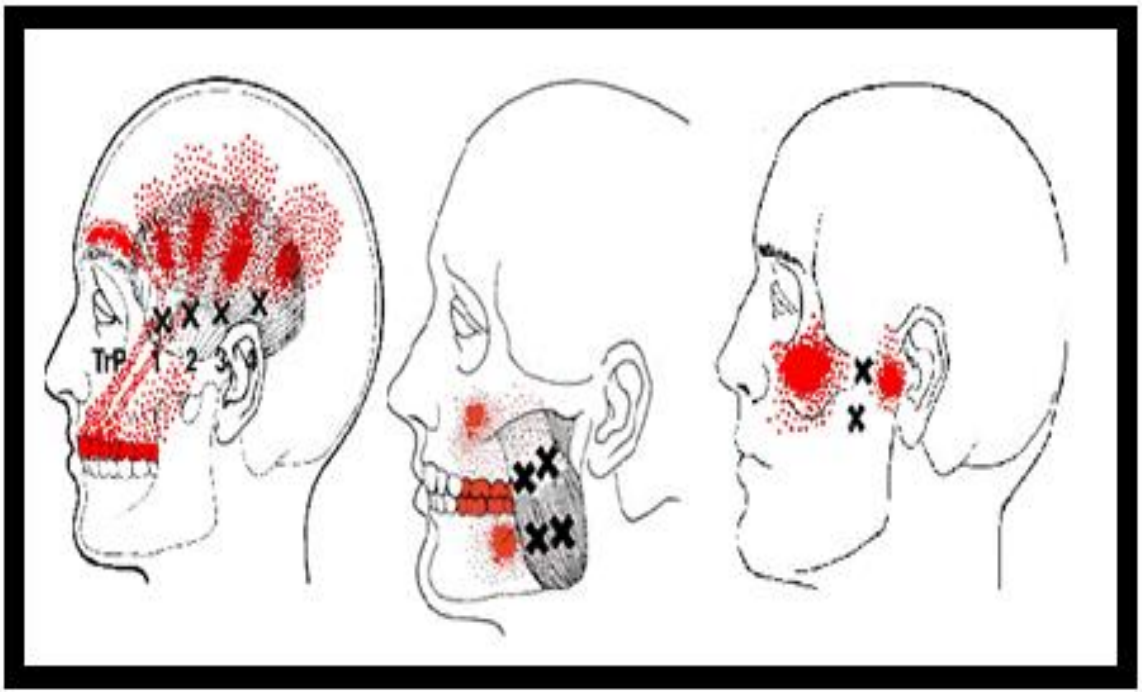


Figure 1-5: Triggers points in masticatory muscles [34]

1.3.5.1 Mechanisms of myofascial pain

Microscopic observation of biopsies from myofascial trigger area explain the muscle hypercontracture consistent with efficient sarcoplasmic reticulum ca++ release with high neural activation. Continue hyperactivity, sarcomere shortening, protein degradation, and myofiber and mitochondrial swelling, with more metabolic and ATP exhaustion [35].

1.4 Review of treatment methods

Most treatment methods for myofascial pain are aim to identify painful trigger Points for restoring normal muscle length, function and strength, thus ablating of muscle spasm.

1.4.1 Individual treatment methods

A. Behaviour-directed therapies

When patient's actions are monitored, physician directs attitude of the patient, thus improving the patient's situation. Many therapies are aiming to change behaviour, including biofeedback-based training, cognitive behavioural therapy (CBT), habit-reversal, self-treatment at home after instruction, progressive relaxation, and self-hypnosis [36].

B. Jaw exercises

Jaw exercises for the masticatory muscles have performed by applying a counter-resistant force to the movement of lower jaw. These exercises aim to activate the motor function by posture and coordination exercise to improve patients' body awareness and reduce loads that adversely affect joints also exercises improves mobility and the length of the muscle and the range of movement of the TMJ; stretching may also help patients overcome feelings of fearing the jaw movements [37].

1.4.2 Clinical treatment methods

A. Occlusal splint therapy

Occlusal appliances have used for making occlusal stabilization and preventing of dentition wear. Muscle relaxation appliance aims to improve the masticatory muscles relaxation, decreasing load on the TMJ, and reduce or prevent the teeth wearing due to bruxism [38].

B. Acupuncture analgesia

It is an effective for the mouth opening restriction and in the relief of muscle pain, without complications, since the blocking of painful stimulus, and proven to be as effective as conventional treatment [39].

C. Arthroscopy

It is a surgical procedure makes a small incision on the TMJ region by an arthrocope. This special tool has a lens and a light on it. It lets doctor see inside TMJ. When general anesthesia is done, the doctor will make a small cut in front of your ear and insert the tool [40].

D. Arthrocentesis

Licensed dentists perform this technique, which involves the insertion of needle that help in irrigation the joint area for debris removal and treat inflammation [41].

E. Botulinum toxin

Botulinum toxin is used for a wide spectrum of disorders characterized by muscle over-contraction, including dystonia, hemi-facial spasm. In maxillo-facial surgery, Botox treats muscular and glandular pathology, as bruxism, spasms and saliva hyper secretion. For bruxism and temporomandibular joint dysfunctions, Botox relaxes the elevators in order to reduce the overload, protecting the joint and relieve pain [42].

F. Ultrasonic treatment:

These waves produce heat at internal level of the muscular tissue; since increasing in tissue temperature leads to blood flow increasing and elimination of metabolic byproducts causing pain. It also may decreases intra-articular inflammation [43].

G. Pharmacotherapy

Even the Initial measures are not enough to relieve TMJ pain dentist prescribes stronger pain relievers. The main role of pharmacotherapy in the management of TMD of masticatory muscles pain is providing sufficient analgesia in order to prevent the pain sensation to rework mastication activities.

The prescribed drugs are pain relieve, anti-inflammatory drugs, muscle relaxants drugs, (NSAIDs), antidepressants, and benzodiazepines [44].

I.Indomethacin

Indomethacin is a non-steroidal that has analgesic and anti-inflammatory effect. It's mechanism, in which inhibiting hormones that cause inflammatory condition and pain. It has indicated for rheumatoid arthritis, ankylosing spondylitis, musculoskeletal disorders. For acute and moderate musculoskeletal pain: Initially 50mg, three times daily for 10-14 days [45].

i. Side effects

Patients taking this medicine complain of vomiting, upset, diarrhea, rectal irritation, dizziness, drowsiness, headache, skin rash, or blurred vision. In pregnancy, any reducing of prostaglandin level may adversely alter the fetal development [45].

ii. Mechanism of Action

Indomethacin has three properties are analgesic, anti-inflammatory ,and antipyretic properties, that cause inhibiting chemotaxis, lymphocyte activity, reducing neutrophil aggregation, and decreasing proinflammatory cytokine levels [45].

iii. Pharmacokinetics

Table 1-1: Summary of Indomethacin cycle in human body [45].

Onset of action:	30 minutes
Duration:	4-6 hours
Absorption	Oral : release: 90% over 12 hours
Distribution:	Vd: 0.34-1.57 L/kg; crosses blood brain barrier
Metabolism:	Hepatic
Half-life elimination	4.5 hours; prolonged in neonates
Time to peak	Immediate release: 2 hours
Excretion	Urine (60%, primarily as glucuronide conjugates); feces (33%, primarily as metabolites)

II. Orphenadrine Citrate and Paracetamol combination

Myogesic is a member of analgesic class. Myogesic as a Salicylate and Antihistamine Combination. It contains the active ingredients Orphenadrine Citrate and paracetamol, working an effective analgesic to remove the pain of acute skeletal muscle mild and moderate intensity. Orphenadrine citrate 35mg and paracetamol 450 mg. Dosage is three times daily [46].

i.The side effects

The common side effects are dry mouth, nausea, blurred vision, dizziness, feeling of weakness, skin reddening, allergic reactions, and breathe shortness [46].

ii.Mechanism of action

As a para-aminophenol derivative and analgesic, antipyretic and weak anti-inflammatory effects. Orphenadrine, as a skeletal muscle relaxant, it is assumed to act on cerebral motor center, even anticholinergic, local anesthetic and some antihistaminic activities are present [46].

iii.Pharmacokinetics

Paracetamol is absorbed in the GI tract with high plasma concentrations take place at 60 minutes after oral administration. The elimination half-life about 3 hours, While Orphenadrine is absorbed in the GI tract. It is excreted in the urine as metabolites. The Orphenadrine half-life has been reported about 14 hours [46].

III. Diazepam

Valium is a benzodiazepine used in treating the anxiety disorders, alcohol withdrawal symptoms, and useful for the relief of myogenic fatigue. Adjunctive dosages are 2-10 mg, and daily it is one to three times [47].

i.Side effects

Drowsiness, fatigue, weakness, also other adverse reaction have reported:

Table 1-2: Summary of Valium side effects [47].

CN System	confusion, depression, slurred speech, tremor, vertigo
GI System	constipation, nausea, GI disturbances
Special Senses	blurred vision, dizziness
Cardiovascular System	hypotension
Psychiatric Reactions	restlessness, acute hyper-excited, anxiety
Urogenital System	Urinary retention, skin reactions

The neonatal respiratory difficulties, or/and hypothermia if mothers have been taking benzodiazepines in pregnancy. Cleft palate is the common reported malformations appears in new-born with maternally overdoses of Diazepam during organogenesis [47, 48].

ii.Mechanism of action

Benzodiazepines is positive allosteric modulators of the GABAA, that binding together to increases the conduction of cl- within the neurons membrane, the result is the reducing neurotransmitter in the brain. Also GABAA receptors have α3 and α5 that contribute to myo-relaxant actions [47].

iii.Pharmacokinetics

Diazepam is absorbed after oral Administration, since the average time to reach peak plasma concentrations is 1– 1.5 hours, while two hours in after a meal. Half-life from The initial distribution phase until elimination phase is 48 hours [47, 48].

1.4.3 Laser in the treatment myofascial pain

Clinical studies of laser therapy direct to effects on living tissues:

1. Laser effects neurons by blocking signals transmitted by nerve cells to the CNS. Laser hits muscle painful points on a non-invasive procedure providing Myogenic Pain Relief [48].

2. Slow healing of nerve functions in damaged tissue can result in numbness. Laser beam accelerates neurons reconnection and raise the action potentials to achieve muscle contraction [49].

3. Laser beam sustains the generation of new capillary vessels in injured tissue that speeds up the healing. Another benefit is acceleration of angiogenesis, which causes temporary vasodilatation [50].

1.5 Laser Basics

- **Light**: The visible region of the electromagnetic spectrum. The sources of ordinary light are known (sun, incandescent and fluorescent lamps).
- **Laser Light**: The laser is acronym **L**; light, **A**; amplification, **S**; stimulated, **E**; emission, **R**; radiation. Laser is light with different characteristics. Lasers have emitted radiation in the UV, visible, and IR regions of the EMS. Three of its fundamental properties are [51]:

i. **Coherence**: It is a term explaining the phase relationship between photons of electromagnetic beam that coming out from laser device at many locations or at different periods (synchronization). This property is strongly related to the ability of waves of light to interference with each other. Two types of behaviour which produced by two coherent waves, which known as constructive & destructive interference [52].

ii. **Collimation**: The laser waves is emitted in paralleling paths that staying in narrow make it possible to send laser with little divergence for long distance.

iii. **Monochromaticity**: Its mean one color and narrow band of wavelengths is radiated. It can be a unique feature of laser [52].

1.5.1 Types and Components of Laser

Development of lasers during the last four decades, since lasers are classified according to structural characteristics and components, as drawn in Figure 1-6.

i. **The optical cavity** (resonator): Optical resonator is a configuration of mirrors arranging on each end of cavity resonator. The function of mirrors is bouncing back of photons to stimulate more photons each time, since one mirror is highly or full reflectance, while the second mirror has less reflectance. There are many types of optical cavities, they are classified depending on the shape of resonators such as spherical, hemispherical, plane parallel, and confocal cavity.

ii. **Active medium:** The part where amplification of photon chain reaction takes place after the atoms are excited by stimulation emission. It can be a solid (Nd: YAG), liquid (dye laser), or gas (CO2). Names of lasers relate to material of active medium.

iii. **Pumping medium:** It is a part of laser device, which transfer external energy and pumps atoms within laser-excited state. It may be optical such as ruby laser or xenon flash tube, also electric discharge, or others [53].

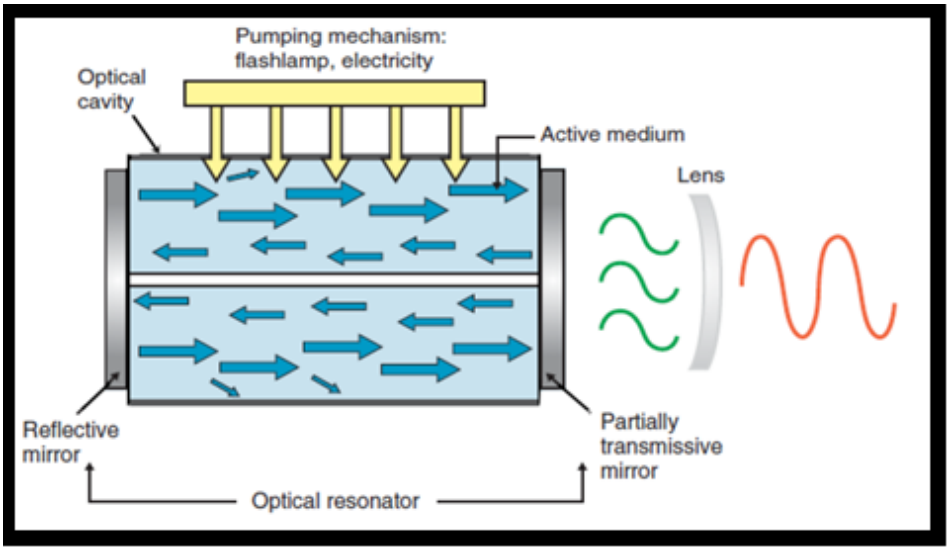


Figure 1-6: Laser cavity [54]

1.5.2 Laser delivery system

The suitable delivery system is appropriate to the characteristics of the laser system on the one hand and the dental application on the other, since delivering the laser energy effectively.

1. **Articulated arms:** Tubes can be rotated about the axis of the mirrors; they are placed at 45^{o} angles. Mainly used with Co_2 laser.

2. **Hollow waveguides**: The tubes are flexible with internal surfaces are reflecting. Commonly used with middle and far- infrared lasers.

3. **Fiber optics:** commonly used with dental lasers. It can deliver laser energy readily more than other types of delivery systems, and used for near infrared and visible lasers. Facilitating using of the invisible dental laser systems, since the aiming beam is accompanying [55].

As myofascial pain laser therapy, near-infrared laser energy transfer to tissue surface for the purpose of pain relief with the specific Deep Tissue Handpiece [56].

1.5.3 Laser operating modes

Dental lasers can emit radiation in two modalities as a function of time. It is either continuous or pulsed as shown in Figure 1-7. These modes are described in details as follows [57]:

1. **Continuous wave mode**: The laser beam is emitted at one power level for as long as the system is on, and it stops all at once when the system is off.
2. **Gated-pulse mode**: a shutter chops the beam periodically, which may be mechanical or computerized.

The shutter is located in front of the continuous beam path. In this mode, the laser energy is the same as in CW mode, except it closes and opens periodically. It can produce pulses as short as microsecond (μs) or millisecond (ms).

3. **Free-running pulsed mode**: The radiation in this system is emitted in a form of optical pulses, rather than CW wave.

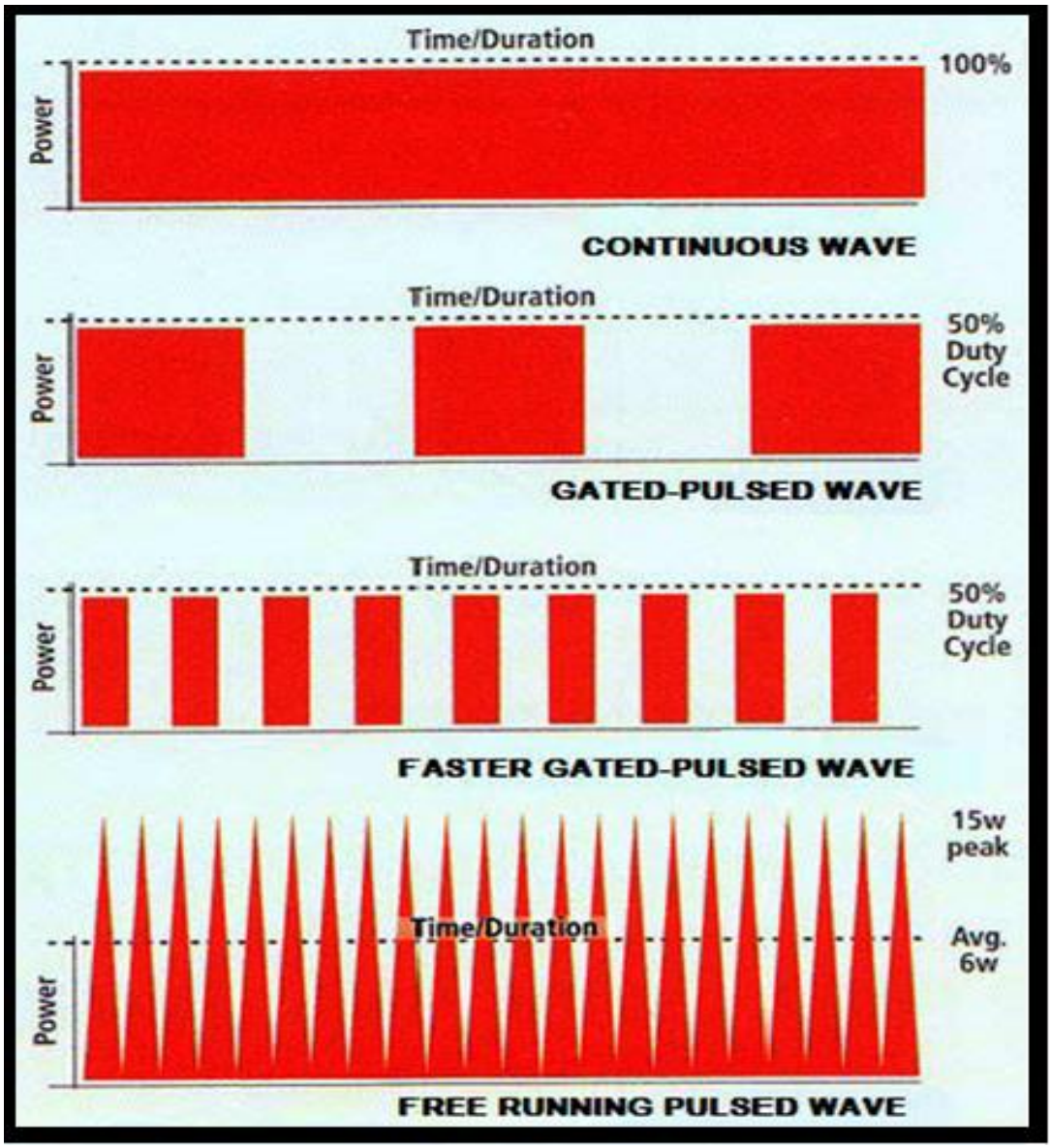


Figure 1-7: Types of laser operation modes [57]

1.5.4 Fundamental terms of laser

- **Laser Frequency** υ (Hz): Is the number of times that the wave oscillates per second.
- **Energy**: it is a pulse energy within irradiation. The units commonly used are joules (J).
- **Power**: it is a continuous power output of continuous wave (CW) lasers. The unit is Watt.
- **Pulse Duration** (pulse width): It is the time of the single pulse in pulsed laser.
- **Spot Size**: It is the diameter of the beam of laser radiation. It influences the number of photons in the exposure area.
- **Pulse Repetition Rate**: It represents the number of pulses / second.
- **Peak Power** (P peak): It is the maximum amount of power that the laser single pulse delivers to matter. P peak = energy of single pulse / pulse duration.
- **Average Power** (P ave): It is the amount of energy released over the period of the cycle. P ave = energy of single pulse * Pulse Repetition Rate (PRR) [68].
- Focused and Defocused lasers: It controls the energy delivered to the area of effect on the target by focal point.
- Focussed mode occurres when the beam hits the target at smallest diameter, while defocused mode occurs when the laser beam is moving the focal spot on larger area of tissue plane, and the beam size has a greater diameter, thus including a wider border of tissue [55].
- Therapeutic Window: The range of wavelengths produces a response on tissue without any damage. Lasers radiate in the UV, visible, and IR regions of ECM. Dental lasers have different wavelengths; each wavelength is absorbed differently by tissue, at different levels and degrees. This is correlated to the penetration depth of the laser [55].

1.5.5 Laser Application in dentistry

Dental lasers waves varies from visible to far infrared. Dental uses for these wavelengths on different fields are shown briefly in table 1-3.

Table 1-3 Types of dental lasers [59]

Lasers	Wavelength range(nm)	Color	Mode of operation	Uses in Dentistry
Nd:YAG (KTP) second harmony	**532**	**Green**	**- Pulsed**	**- Coagulation/ hemostasis. - Dental bleaching - Composite curing - Caries diagnosis**
He-Ne	**633**	**Red**	**- CW**	**- Laser Doppler flowmetry - Desensitization - Hemostasis.**
Diode laser (low –level, non-surgical)	**635 655**	**Red**	**- CW - Gated pulsed**	**- Caries detection - Biostimulation - Periodontal inflammation**
Diode laser	**810 940 980 1,064**	**Invisible (near infrared spectrum)**	**- CW - Gated pulsed**	**- Bacterial decontamination - Soft tissue surgery (incision and ablation) - Desensitization - Periodontal pocket treatment**
Nd:YAG	**1,064**	**Invisible (near infrared spectrum)**	**- Free running pulsed - CW**	**- Bacterial decontamination - Soft tissue surgery (incision and ablation) - Periodontal pocket treatment**
Ho:YAG	**2100**	**Invisible (near infrared spectrum)**	**- Free running pulsed**	**- Arthroscopic surgery for TMJ. - Soft tissue surgery. - Bacterial Decontamination**
Er:YAG	**2,940**	**Invisible (mid infrared spectrum)**	**- Free running pulsed**	**- Bacterial decontamination - Soft tissue ablation - Subgingival soft tissue curettage - Scaling and root debridement - Hard tissue conditioning - Hard tissue ablation.**
Er,Cr:YSGG	**2,780**			
CO_2	**10,600 9,600**	**Invisible (far infrared spectrum)**	**- CW - Gated-pulsed**	**- Soft tissue incision - Subgingival soft tissue curettage - Dentinal hypersensitivity**

1. Diagnosis: [60]

a. Detection of pulp vitality.

b. Laser fluorescence- detection of caries, bacteria, and dysplastic changes in the diagnosis of cancer.

2. Soft tissue applications: [61]

a. Bacterial decontamination.

b. Soft tissue, curettage and periapical surgery.

c. Gingivoplasty and Gingivectomy.

d. Frenectomy.

e. Implant exposure.

f. Coagulation/ Hemostasis.

g. Pulpotomy, pulpectomy, and pulp capping.

h. Removal of fiberplastic tissues and fibroma.

i. Tissue fusion.

3. Hard tissue applications: [62, 63]

a. Caries removal and cavity preparation.

b. Re-contouring of bone (crown lengthening).

c. Endodontics: (root canal preparation, .sterilization, and Apicectomy)

d. Laser etching.

e. Caries resistance.

4. Laser activation: (composite curing, bleaching agent activation) [60].

5. Laser induced analgesia: (Biostimulation)

The pain therapy is process which tissue elevates temperature, causing the temporary increase in blood circulation, then the temporary relaxation of muscle, as distance of penetration inside of biological tissues. (Figure 1-8) [64].

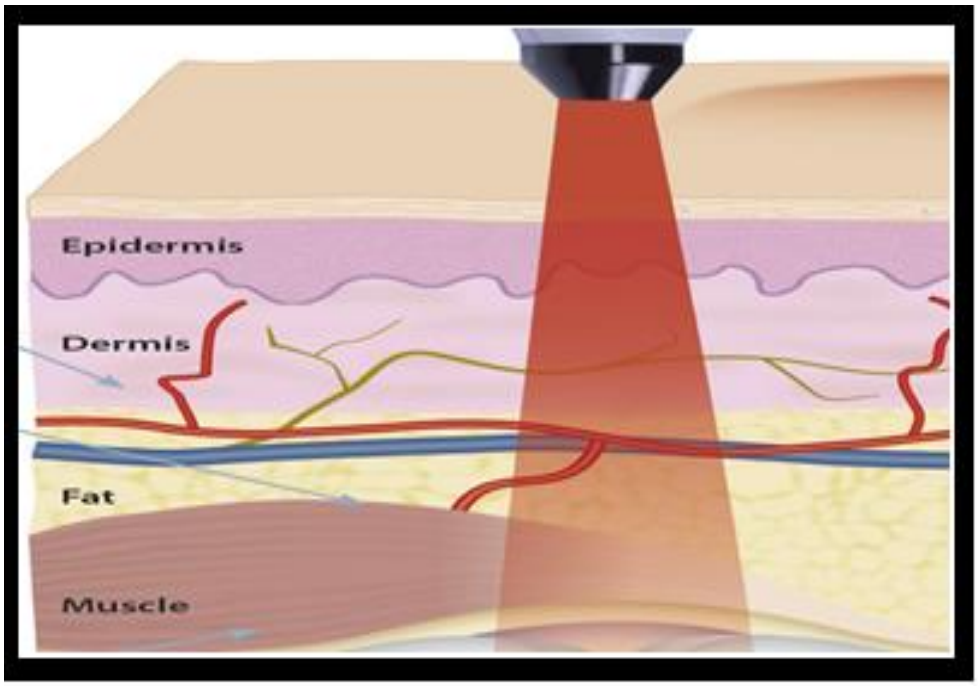


Figure 1-8: Irradiation within tissue [64]

1.5.6 Low Level Laser Therapy

LLLT is the application of laser in red and near infra-red regions over defects , since it accelerates the speed, increase tensile strength of repaired tissue , improving tissue reparing, anti-inflammation and allow relief for acute and chronic pain (analgesia) [65].

Laser exposing should be not followed by overheating effect or thermal damage, also targeting is according to penetration depth of each wavelength (Table 1-4) [66].

LLLT has photochemical effect. When using the optimum intensity and times, red-near infrared beam inhibits oxidative products and increases ATP, and improves cell metabolism also reduce inflammation. One of this important effect is an Analgesia, it's mechanism works better if a continuous beam is applied [67].

The mitochondria produces nitric oxide (NO), when cell be stressed due to fault. This causes displacing of oxygen from cytochrome c oxidase and reducing ATP, causing increasing (ROS) and resulting in oxidative stress, that leading to inflammation and cell death [68].

Within the mitochondria, absorption of light in cytochrome c oxidase, breakdown NO lead to oxygen restore, thus ATP is more produced and oxidative agents reduced, mitochondrial function is reactivate then cellular metabolism is going normal, and the defect heals better more quickly [69].

Diode therapeutic laser energy penetrates much more deeply into tissues others have a much more limited penetration capability. The first thing to consider if laser will reach the targeted tissues.

Table 1-4: Penetration depth of Near Infrared wavelengths [70].

Wavelength	Penetration depth
Visible Red (630-700 nm)	0.5-1 cm
Near Infrared (700-800 nm)	2-3 cm
Near Infrared (800-970 nm)	3-4 cm
Near Infrared (970-990 nm)	1-2 cm
Near Infrared (990-1200 nm)(potential deeper penetration in Q-switched mode)	4-6 cm

1.6 Laser—Tissue Interactions

When laser irradiation hits the tissue surface, it is absorbed, scattered, transmitted, or reflected back. The reflected beam excluded off the tissue surface and counted as losses. From this reflected beam comes the hazard of lasers [71].

The **Scattering** means that the irradiation bounces from molecules inside the tissue. It is inversely related with **absorption**; when absorption is high, the scattering is less. When it is high, it distributes the energy of laser over a larger volume of tissue [71].

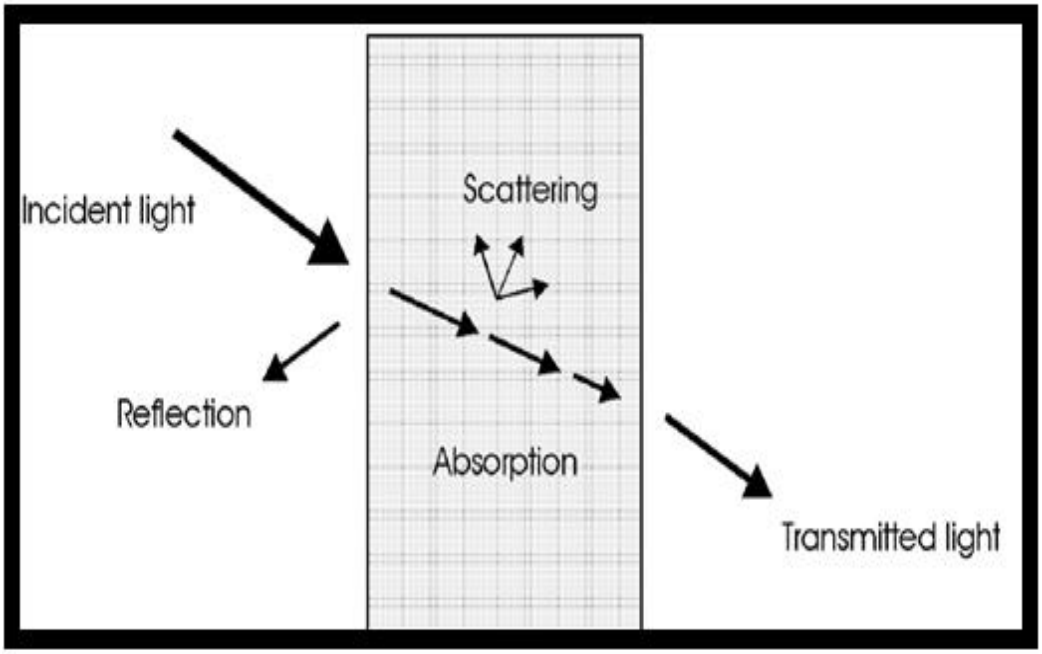


Figure 1-9: The effects that happen when light interacts with matter [72]

The **Transmitted** beam is that part of irradiation that travels through and beyond the tissue boundary without any effect on tissue and because of that, the surrounding tissues must be quantified and all effects should be considered before stating the treatment. In the figure 1-9 main theses interaction are illustrated [71].

The most important part of the beam that does all the effect is the absorbed beam that is responsible of the real laser effect on target tissue. Each wavelength has distinct effect on dental structures (the chromophores). Interactions between laser and target are depending on unique factors. The effect of laser could vary from no effect to complete ablation. In Figure 1-10, the main absorption wavelengths in dentistry [73].

A .Tissue Properties

According to the nature of tissue like color, pigment content, vascularity, chemical composition [74].

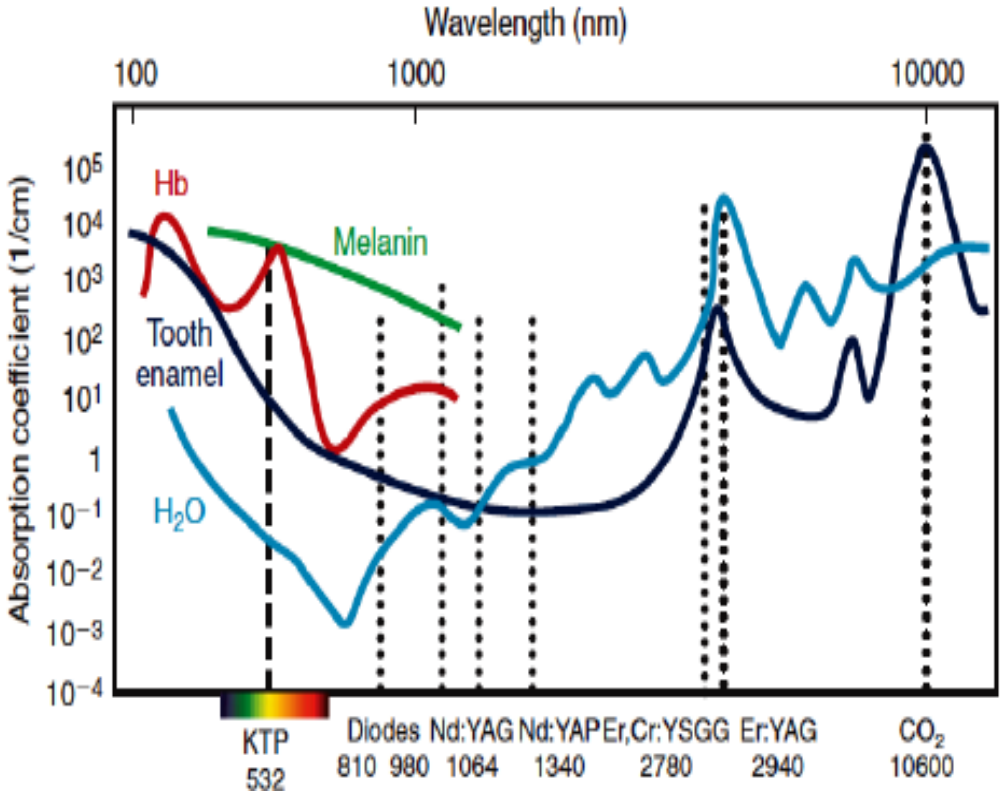


Figure 1-10: Dental Lasers Wavelengths on Spectrum with the absorption curves of the main dental chromophores [55].

The tissue properties include:

1. Optical tissue properties; which include the coefficients of reflection (Albedo), absorption and scattering.

2. Thermal tissue properties; thermal conductivity and heat capacity.

3. Tissue photosensitizes whether endogenous or exogenous (H_2O, Hb, melanin, protein).

B. Laser Parameters [75].

Determining laser parameters for optimum results is a critical point in each type of procedure. This depends on the type of laser used, which is affected by the following:

1- Laser wavelength.
2- Exposure time.
3- Energy density and power density.
4- Spot size.
5- Focusing and defocusing of beam.
6- Pulse duration.

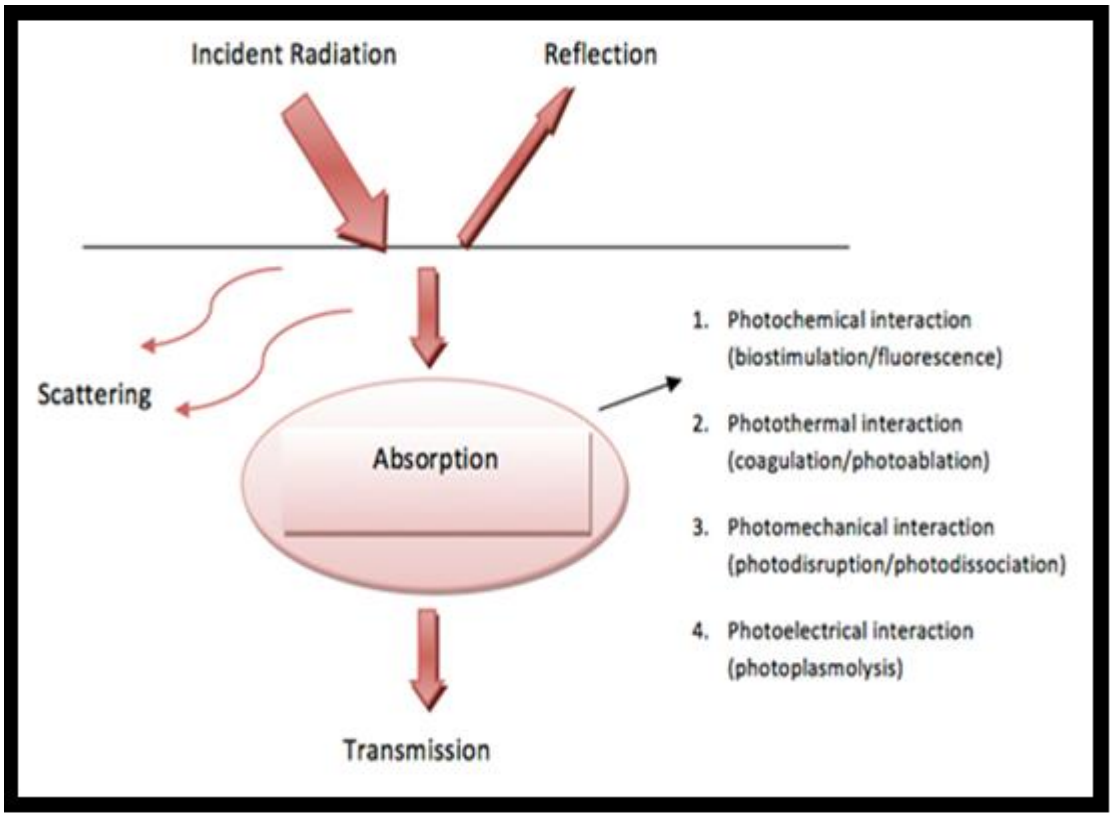


Figure 1-11: the interactions of laser light in tissue [74]

1.6.1 Laser-Tissue Interaction Mechanisms

The exposure time with power density are conclusive parameters for selecting a bioeffects of laser. The pulse duration play a key role responsible for type of mechanisms, these mechanisms are divided into (Figure 1-12) [76]:-

A// wavelength dependent interaction mechanisms.

B// wavelength independent interaction mechanisms.

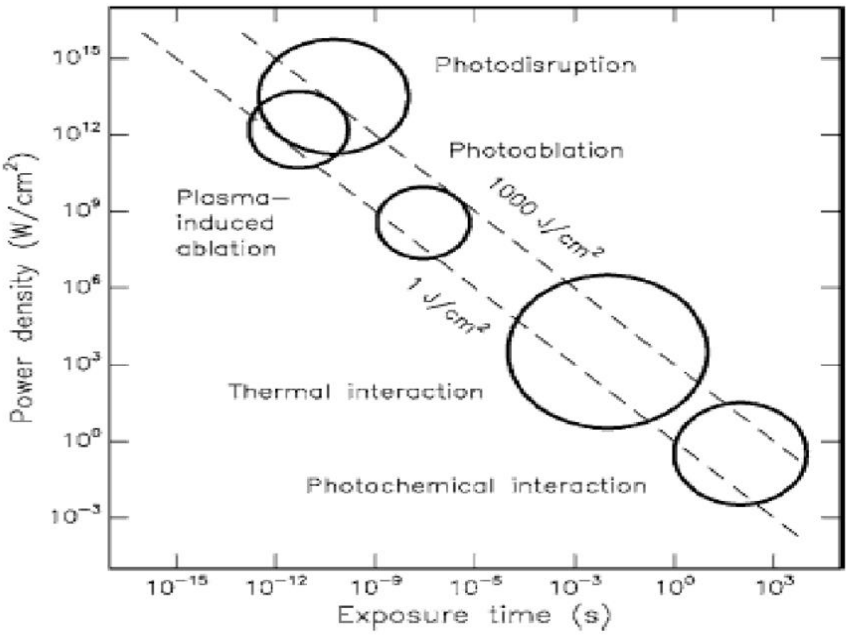


Figure 1-12: Laser tissue interaction mechanisms [76]

1.6.1. A Wavelength—Dependent Interactions

1. Photochemical Interactions

These interactions occurs with long exposure times and low power densities (no more 1 W / cm^2). The irradiation has chemical effects during certain reaction with specific molecules in tissue. In this mechanism, radiation distribution inside tissue is determined by using the scattered beam. It plays a significant role within photobiomodulation, photodynamic therapy, tissue fluorescence, and photodetected [74].

i. Photodynamic Therapy

Spectrally adapted photosensitizer at this reaction and it is injected into the target body. Resonant excitation by laser may then trigger the photosensitizer to perform targeted photochemical reactions, resulting in biological action. The end of these reaction chains, highly cytotoxic reactants (singlet oxygen) are released an irreversible oxidation of essential cell structures. Tumor diagnosis depends on the concentration level of photosensitizer, using time-resolved fluorescence technique.

Diagnosis and therapy of abnormal cells with photosensitizers is one of the key advantage of Photodynamic therapy. The antimicrobial aim of photodynamic therapy improves microbial reduction during conventional method in different dental procedures [74, 77].

ii. Photobiomodulation

The healing of wounds, reduce inflammations and pain relief by red and/or near-infrared lasers (helium–neon and diode lasers) were documented. Increasing macrophage activity in target areas with appearance of haematomata, accelerate resorption of edema and supported autoimmunological reaction. [78].

2. Photothermal Interactions

Photothermal effect induces the most of the surgical applications of lasers, since rising in tissue temperature as result to absorption of laser radiation. Thermal effects can done by either CW or pulsed laser radiation and their effect ranges among coagulation, vaporization, carbonization, and melting.

At 37◦C is body temperature, and for 5◦C of heating changes will occur, elevation in temperature (10 °C) can alter the activity of enzymes and cause changes in circulatory blood and vessel permeability [73].

Hyperthermia: Tissue temperature is raises above normal without destroying, at tissue temperature approximately 42–50◦C, thermally affecting of tissue and molecular changes of proteins are occurred by bond destruction have a benefit in Photobiostimulation.

Coagulation: At 60-70◦C, proteins and collagen denaturation causing the coagulation and necrosis of cells and tissues. Denaturation begins at temperatures just above 60◦C.

At 70–80°C, result in an unfolding of the collagen components and their twisting with adjacent segments, even adherence of soft tissue due to alteration by heat-induced in collagen.

At 80°C—85°C, shrinking in blood vessels due to the alteration of the collagen within walls (hemostatic action of lasers) [79].

Vaporization: inter and intracellular water content in soft tissue is begun to vaporize at 100°C. Micro-explosions result from jet of steam expanding, explodes the surrounding molecules, and make smaller, which can support the ablative process of the irradiation by dissociating components of large tissue. The thermal decomposition is important mechanism in hard tissue ablation and removal layers of tooth [73].

Large spot size and high power density, these conditions determine achieving tissue removal. Laser cutting is linear vaporization resulted by high power density and small spot size. Efficient cutting is achieved by moving the beam yet that minimizes secondary thermal effects in the adjacent tissue [73].

Carbonization: occurring when applying excessive energy and vaporization of water molecules is done and continued laser exposure. Exceeding 100◦C, carbonization may begin until carbon is released leading to change the adjacent tissue color to black. To avoid carbonization, cooling of tissue is effective with either water or gas. For medical laser procedures, carbonization reduces visibility during surgery, thus in any case carbonization should be avoided [73].

Melting: can occur over 300◦C, and according on the target. At Molecular level, thermal work when absorption has done in vibration–rotation band followed by nonradiative decay, changing photon energy to another type of energy of a molecule, it is called kinetic energy. Thermal damage begin in the adjacent area, it is minimal if the wavelength has completely absorbed by the target with the shortest thermal relaxation time [79].

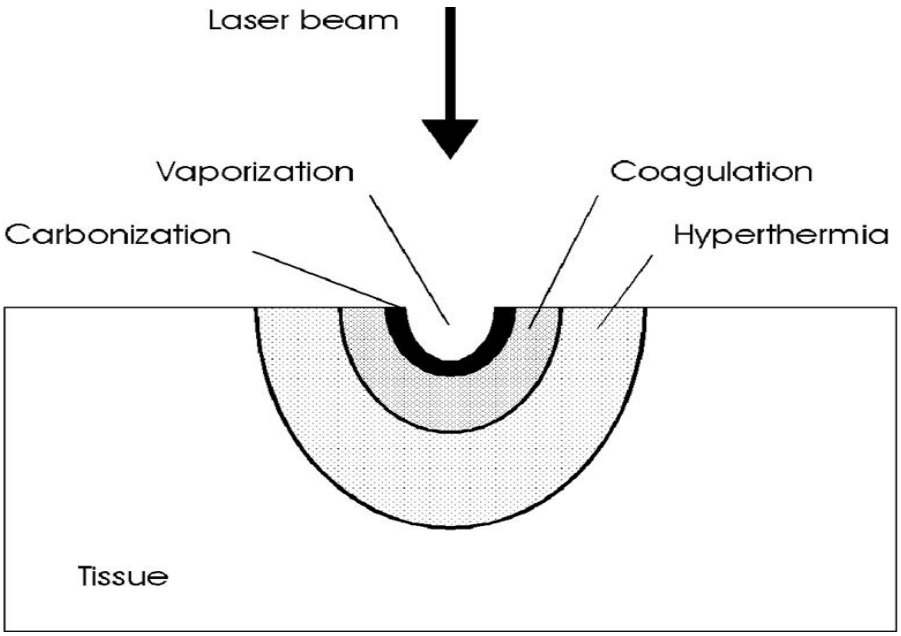


Figure 1-13: Location of thermal effects inside biological tissue [76]

3. Ablative Photodecomposition

Photoablation occurs when material is decomposed during exposing to high intense UV laser. The ablation pattern is determined the spatial parameters of the laser. The key advantage is lack of thermal damage to adjacent tissue.

Only when photons from ultraviolet laser (wavelength < 350 nm) are absorbed, the energy gain is high enough to reach an electronic level that pass bond energy dissociating chemical bonds at the very next vibration [73].

1.6.1. B Wavelength—Independent Interactions

These interaction mechanisms depend on plasma generation, at high power density 10^{11} W/cm2 associated with lasers operating in short pulse duration (nanosecond, picosecond, femtosecond) .

1. Plasma—induced Ablation

In general, it is produced by plasma ionization. It is represented by popping sounds during laser shooting. The key parameter of this producer is the high peak intensity, which assesses when breakdown is occurred and the ionization of molecules is achieved. It is also associated with plasma formation and shock wave generations inside the tissue, which all leads to ablation. In dental therapy, this technique was used efficiently with hard tissue in very precise manner [74].

2. Photodisruption

The optical breakdown occurs at the same time with two effects are shock wave generation and cavitation. If this occurs inside the soft tissue, an additional cavitation (jet formation) occur. Cavitation occurs when the laser beam focusing is inside the tissue rather than on its surface. A gaseous bubble full of water vapor is diffused against the surrounding tissue. The cavitation collapse or rupture of this bubble due to adjacent solid boundary causes jet formation, and tissue ablation [74].

1.7 Laser safety and hazard guidelines

1.7.1 Laser classification [80].

Class 1: These laser systems cannot emit laser radiation at level that may cause skin or eye damage during operation.

Class 1M: These systems do not produce any hazardous radiation during normal operation unless viewed with optical collimators.

Class 2: these lasers are in the visible range, emit lasers at lowest level harmful to eyes, and skin within the human eye of aversion response time (0.25 s).

Class 2M: These laser systems emit laser at visible spectrum and cause eye hazard if viewed with collimated optics.

Class 3R: The laser systems that become hazard if viewed by eyes; directly or by reflection, especially if the eyes are focused and stable.

Class 3B: These laser systems may be visible or invisible, with medium powers. They cause potential eye hazard when viewed directly or by reflection, with no hazard for eye or skin by scattered radiation, except for high power lasers with certain wavelengths.

Class 4: These lasers with high powers (visible and invisible), with acute hazard for eye and skin in direct, reflected, or scattered exposure. For fire and by-product emissions from target to process materials, they have hazard considerations. All dental and medical laser systems belong to this class [97].

1.7.2 Hazards in Laser Dentistry

A. Hazard of laser on eye (ocular damage)

It is mandatory to wear a laser protective eyewear, since laser can damage the eye by all class 3B and 4 laser systems. The operator and the exposed person should both have eye protection. The visible and near IR lasers (400-1400 nm) can cause retinal damage, mid IR lasers may harm the lenses and the Aqueous Humor, and far IR harms the cornea, as shown in the figure 1-14. UV lasers have primarily absorbed by cornea and cause damage and impairment of vision, the appropriate eyewear must have the wavelength and optical density for the laser with labels on frame. On dental laser operations, the specular reflections should be eliminated, or carbonized or non-reflective instruments must be used. [80].

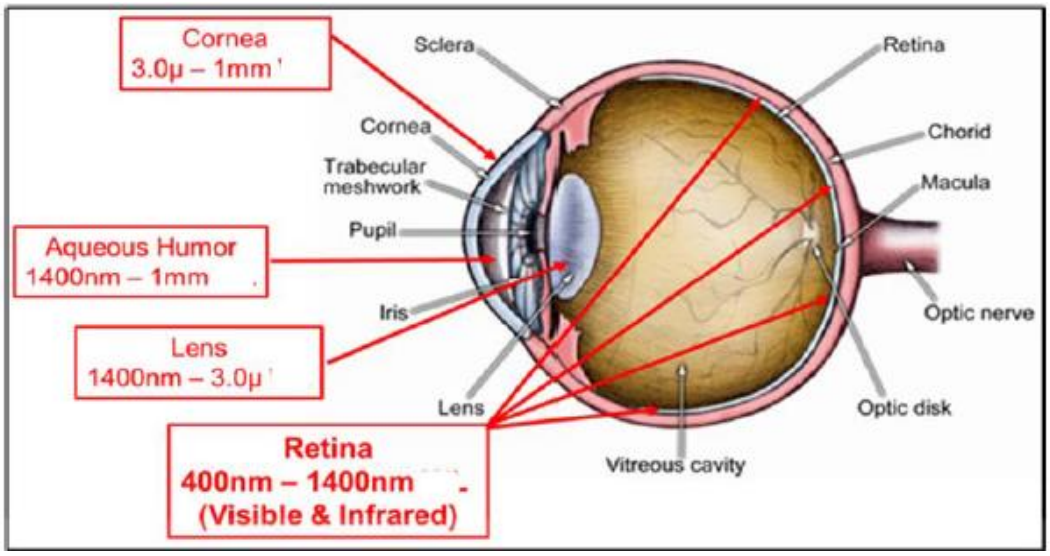


Figure 1-14: Potential eye damage from laser energy [80]

B. Hazard of laser on Skin

IR lasers may cause thermal burns or dry skin, while UV lasers may cause erythema, skin cancer, or accelerated skin aging.

C. Hazards of laser on Respiratory System

The inhalation of laser plume by the operator is hazard and it is called Laser Generated Airborne Contaminants (LGAC). The plume may contain vital stains of Human Papilloma Virus or any other organisms. This hazard can be controlled by using a high volume evacuation system during irradiation to clear the plume; also, the operator should wear a surgical mask **[81]**.

D. Hazards of Fire and Explosions

The laser systems include some flammable solids, liquids or gases that may pose significant hazards, and easily ignited if exposed to laser beam **[82]**.

E. Hazards of Electric shock

The Class 4 laser systems have high powers, so there is a chance of electric shock hazards. If the lasing is directed to oral soft tissue, the tooth should be protected **[82]**.

1.7.3 Laser controlling area warning signs [80].

The purpose of the warning signs is to convey a rapid visual hazard-alerting message to the others that there is a laser system hazard in the area, and many protocols should by followed (Figure 1-15). These protocols include:

- The laser system should be positioned in side-room- Warning signs should be big, colorful, and in obvious position.

- Knocking before entering.

- Light signs should be illuminated during using.

- Laser Eye Protection Wears should be available.

- The area should be restricted for authorized persons only.

- The operator should have enough training about the laser system.

Figure 1-15: Warning signs of laser field

1.8 Literature review

1.8.1 High power laser therapy

HPL is used in pressing across the tissues, since laser stimulates the process of tissue healing. In this context, the tendency of the researchers to favour high-intensity laser patterns was initially expressed for its ability to relief pain incidentally, only the mechanism of action that is based on thermal ablation of tissue components, especially for neuronal receptors, cellular membranes ,and the intracellular proteins have been constrained as a result of this belief [83].

From the observations, the effectiveness of high-intensity laser was short-lived, and have no role in healing, as well as risks that may hurt both the patient and the treating doctor [84]

1.8.2 Low -intensity laser therapy: -

Through the review of the literatures can be seen many names that call this treatment:-

1) Low level laser Therapy (LLLT).
2) Soft Laser Therapy (SLT)
3) Cold laser therapy (CLT)

Low-intensity laser therapy is defined as a non-invasive cure by photons. The low absorption rate of the laser light by the human skin allows it to penetrate deeply through the tissues, where it exhibits the effect of Photobiostimulation [85].

1.8.3 Effect of low-intensity laser treatment in TMJ pain therapy

Many studies about low laser level on treating TMD have published. The investigators identified many trials that met the inclusion criteria. Outcomes of LLLT trails for treating TMJ pain are inconsistent. Carrasco worked on patients with TMJ pain and one defined trigger points in the masticatory muscles. Three groups subjected to laser treatment at different level of energy for each. At final session, the analgesic effect was documented [86].

Venezian worked at patients, with myofascial pain in many doses of laser and placebo 2 / week for 4 weeks. EMG for two groups is done, and it showed no difference. VAS scores declined after a laser treatment [87].

1.8.4 Lasers in the treatment of myogenic TMD

Several studies on laser therapy for TMJ pain have been published. Most studies were achieved with LLLT and not high irradiation protocols.

A. Nd: YAG (1064 nm)

In 1998, Takahashi et al used Nd: YAG low power laser in treatment of TMD'S. Although defocused mode, he observed significantly decreased pain, and good improvement in mouth opening [88].

B. Helium Neon (632.8 nm)

In 2007, Emshoff assessed He-Ne laser therapy in the treatment of TMD. All groups showed low improvements in pain relief during function [89].

C. Red laser (660 nm)

Shirani reported that using of wavelength 660 nm (InGaAIP visible red light) had less effect on pain reduction in patients with myofascial pain dysfunction [90].

D. Diode laser

From 1990 to the present, there have been many attempts by scientists to treat the pain of the musculoskeletal joint by laser diode. Different types of diodes were used; 780 nm, 810- 830 nm, and 904 nm.

In 2014, Chang used LLLT for TMJ pain. Experiment was compared, LLLT with placebo. The pain reliving is measured using pain scale; it was decreasing [91].

In 2015, study by Chen et al evaluated pain and functional activities with laser for TMD. This research provided feedback on pain, measured by a VAS. They found significantly better functional active mouth opening [92].

1.9 Aim of study

The purpose of this study was to evaluate the therapeutic effects of diode laser at 940 nm compared to pharmacotherapy in the treatment of myogenic origin TMJ disorders.

CHAPTER TWO: Materials and methods

This chapter will begin with the materials and equipment used in this study then the required methods and protocols within criteria for study population, sample size estimation, and assessments. Specifications, standardisation and calibrations of machines will also be briefly described. Then statistical analysis methods will be mentioned.

2.1 Materials

2.1.1 Clinical instruments of study (diagnostic tools)

1. Dental mirror
2. Dental explorer (probe)
3. Kidney dish
4. Vernier calliper Figure 2-17 (TOPEX, Warsaw, Poland), the specification are:
    a. Resolution: 0.01 mm.
    b. Measurement accuracy: ± 0.02 mm

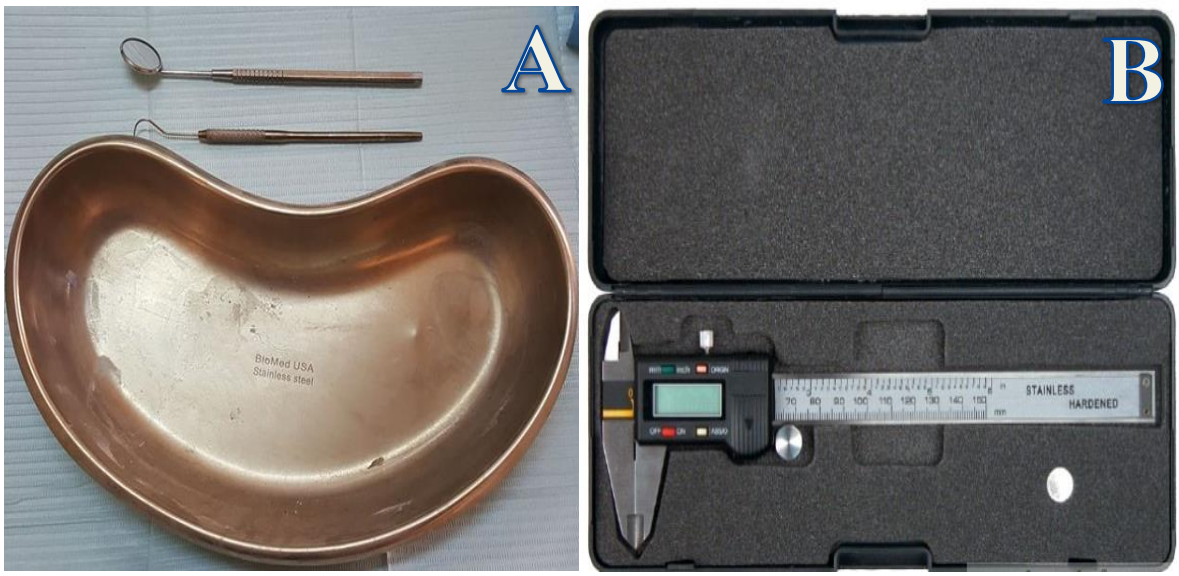


Figure 2-1 Instruments used in diagnosis: A kidney dish, B Digital Vernier

2.1.2 Medications

A. Medications of pharmacotherapy

1. Orphenadrine Citrate and Paracetamol combination

2. Indomethacin

3. Diazepam

B. Desident spray CaviCide (SpofaDental , Czech Republic)

Antiseptic has used to clean the Hand Piece head before and after the laser would be applied to the patient.

2.2 laser system

The 940 nm Epic 10 diode laser (Biolase, USA) has the following specifications:

1. The main components, Figure 2-4:

a. Base console.

b. Delivery system, consist of :

i. Re-useable Fiber Optic Assembly

ii. Re-useable Deep Tissue Handpiece.

iii. Dust cover

c. Wireless footswitch.

2. Power mode: CW mode

3. Time of exposure: 5 minutes (Maximum)

4. Laser classification: IV (4)

5. Medium: InGaAsP Semi-conductor diode

6. $\lambda = 940 \pm 10$ nm

7. Maximum power output = 10 W

8. Aiming beam (visible diode laser)

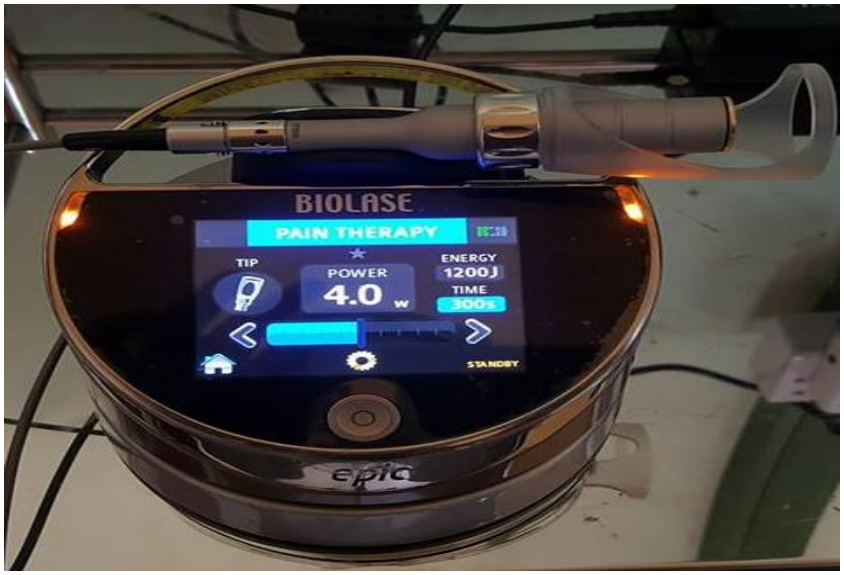


Figure 2-4: laser system

2.2.1 Deep Tissue Handpiece

It is reusable and equipped with a disposable non-sterile protective shield for single use. Laser delivery was via Deep Handpiece (Figure2-5).

Figure 2-5: Deep tissue handpiece (defocusing)

As expectation, losses in the output power is observed, so the irradiation power was measured by power meter device (Gentec Electro-Optics Quebec City, Canada), (Figure 2-6).

Figure 2-6: Powermeter

2.3 Methods

2.3.1 Samples collections

The study included forty patients (40) aged between 25 & 54 years patients who visited the dental clinic in the Institute of Laser for Postgraduated Studies, Al Wasity Teaching Hospital, and Pure Therapy Centre with the pain in TMJ region and mouth opening limitation. Selected cases have examined clinically within the required criteria.

2.3.2 Sample divisions

All patients had assigned into two groups:

1. Group A: laser therapy patients (n=25)

2. Group B: pharmacotherapy patients (n=15)

2.3.3 Pilot study experiment (Skin color)

This experiment was done to detect the optimum and harmless effect of irradiation, therefore the laser power, exposure time, and the distance from the skin with different patients have tested, referring to the Fitzpatrick Skin Type Scale when performing pain therapy procedures (Table 2-1).

Table 2-1: Fitzpatrick skin type scale [93]

Fitzpatrick Skin Type Scale	
TYPE I	Highly sensitive, always burns, never tans. Example: Red hair with freckles
TYPE II	Very sun-sensitive, burns easily, tans minimally. Example: Fair-skinned, fair-haired Caucasians
TYPE III	Sun-sensitive skin, sometimes burns, slowly tans to light brown. Example: Darker Caucasians
TYPE IV	Minimally sun-sensitive, burns minimally, always tans to moderate brown. Example: Mediterranean-type Caucasians
TYPE V	Sun-insensitive skin, rarely burns, tans well. Example: Some Hispanics, some Blacks
TYPE VI	Sun-insensitive, never burns, deeply pigmented. Example: Darker Blacks

The skin classification stated in 1975 by Fitzpatrick. This classification system are necessary in dermatology. Skin scale is a test estimate race disposition and response to sun exposure. The diode wavelength has increased absorption in melanin, causing greater heat of the skin surface of patients. Patients with more melanin content in their skin feel more discomfort during treatment [93]. The patients selected for this study were the third and fourth type to include the largest segment of Iraqi society.

2.3.4 Dose adjustment

The distances from skin to temporomandibular components vary from 1.5 to 5 mm. The wavelength relates to the penetration of the laser. Infrared lasers possess a penetration depth reach to 20 mm [94].

2.3.5 Samples preparation of pilot study

Six samples had divided into three groups. All patients with tan skin had exposed to 940 nm diode laser:

Set A: 4 W, 2 seconds/ trigger point, 1cm distance from end DHP to target area.

Set B: 4 W, 2 seconds/ trigger point, 2cm distance from end DHP to target area.

Set C: 4 W, 2 seconds/ trigger point, 3cm distance from end DHP to target area.

2.4 Laser parameters

Laser penetration through biological tissues depends on two factors:

1. Distance from skin to target.
2. Area of the affected target.

Power density (CW) = power/spot area [94].

The desired effect was at Set C with 940 nm, comfortable to patient, since no thermal damage, also these parameters were effective during the laser therapy session:

- Average Power: 4 watts.
- Exposure time: 2 seconds / trigger area.
- Power density : Max Power Density 0.566 W/cm^2
- Spot size: 30 mm.

2.5 Diagnostic methods used in the study

2.5.1 Pain Measuring

All patients have been asked subjectively to the intense of pain on VAS, and according to the following VAS:

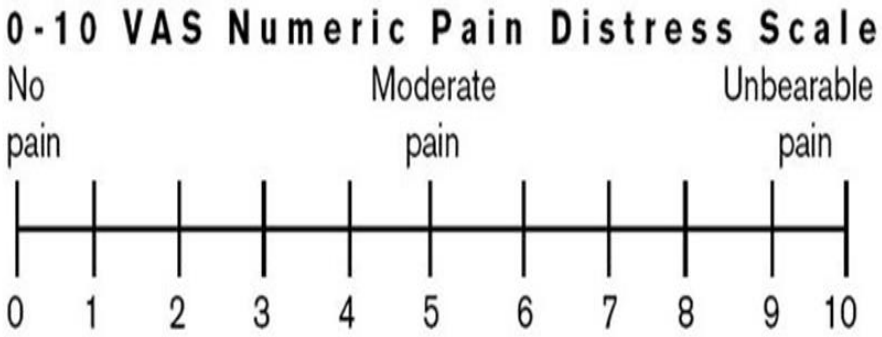


Figure 2-7: Visual analogue scale [95]

2.5.2 Mouth opening measuring

Digital measurement used to evaluate the mouth opening, patients were asked to open their mouth as wide as possible, while measuring the maximum distance from the incisal edge of the maxillary central incisor to incisal edge of mandibular central incisor at the midline. Six readings were taken of MMO in millimeters (mm).

- Under 40 mm is non-functional opening (limitation)
- 40 mm and over is functional opening

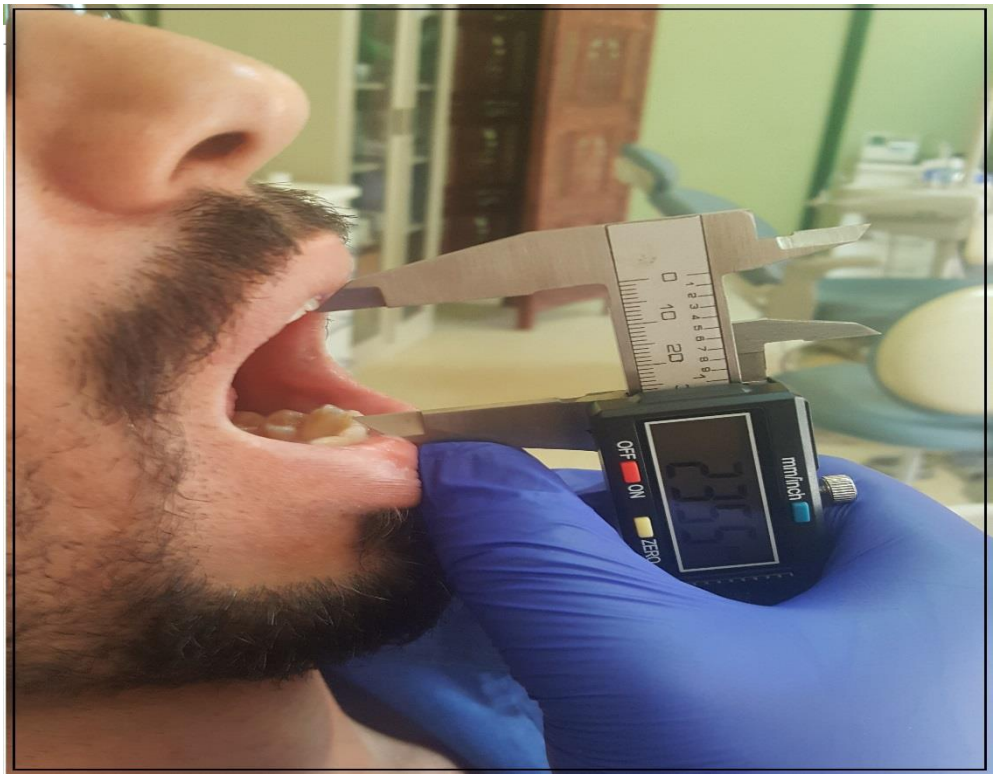


Figure 2-8 A: Maximum Mouth opening measuring

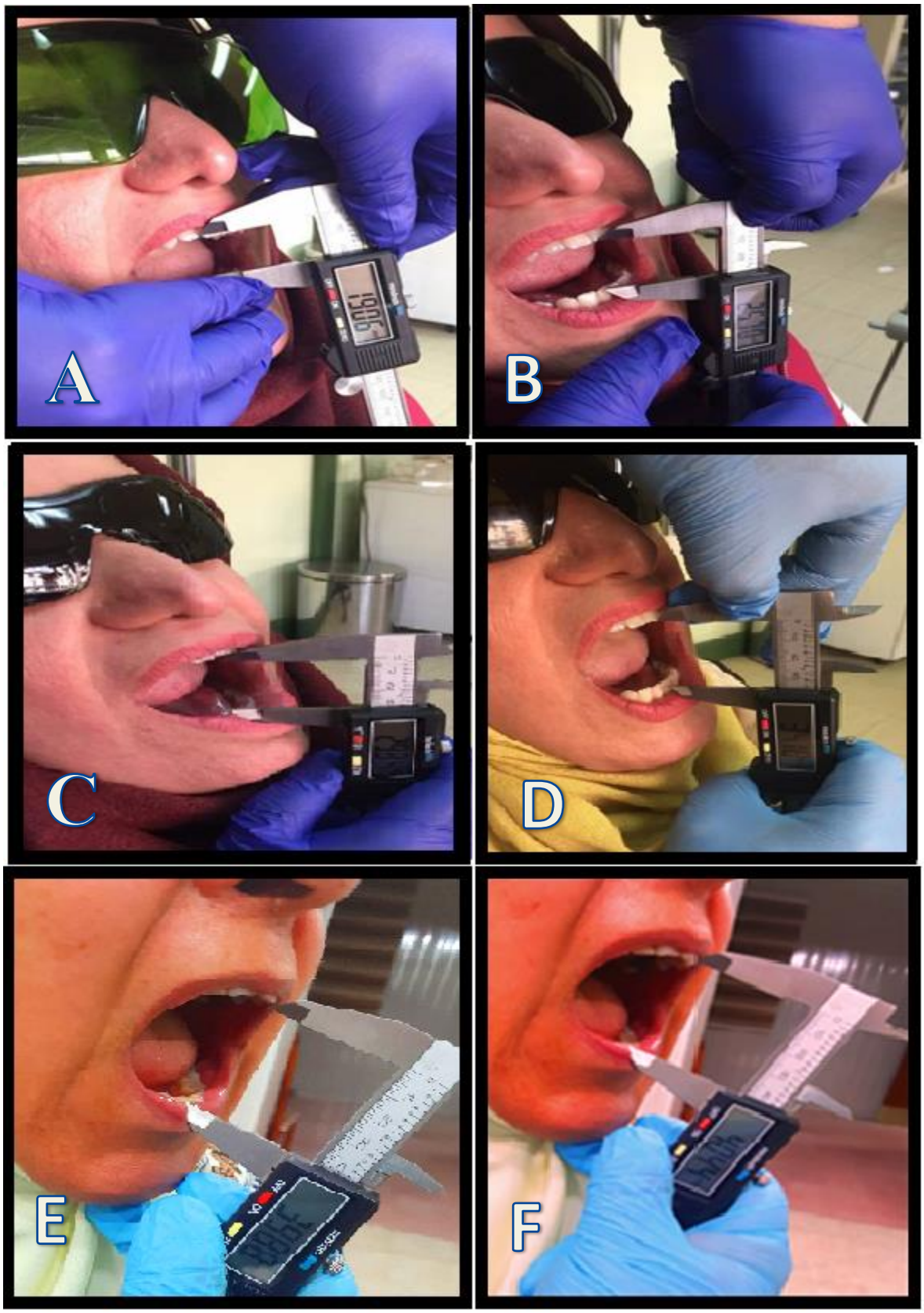


Figure 2-8 B: Measure the mouth opening A: pre-treatment, B: after first session, C, D: after one week, E, F: pre and post therapy (two weeks)

2.5.3 Trigger points detection

The trigger points on each muscle were determined. By performing the standardized palpation of four included muscles, judging the clinical relevance of TP(s) using clinician assessment.

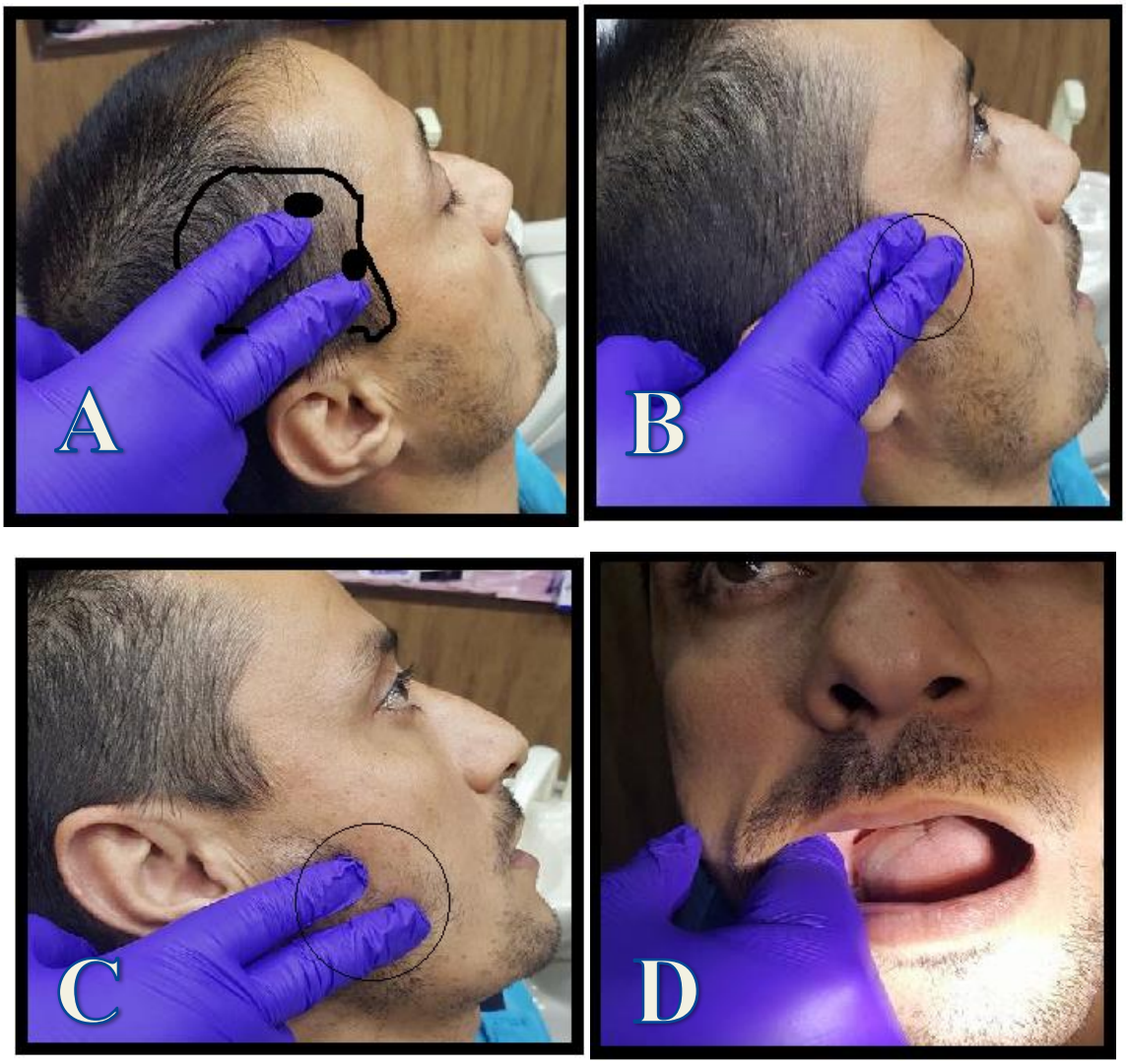


Figure 2-9: Detection of trigger points or painful area on masticatory muscles by palpation

A: Temporal region, B: TMJ region, C: Masseter region, D: Pterygoid region

2.5.4 X ray Diagnosis (OPG)

Inclusion criteria were applied in the selection of patients. As panoramic X-ray of jaws and the teeth, OPG should be taken to exclude the undesired cases and leaving the other dental and surgical aspect out of this study (figure 2-10). During OPG scan, the rotated unit around the patient's head. Scanning and exposure time vary from 10 to 15 seconds **[96]**.

An OPG has benefit to show

- Many types of fractures
- Dislocated jaw
- Oral Infection
- Dentition

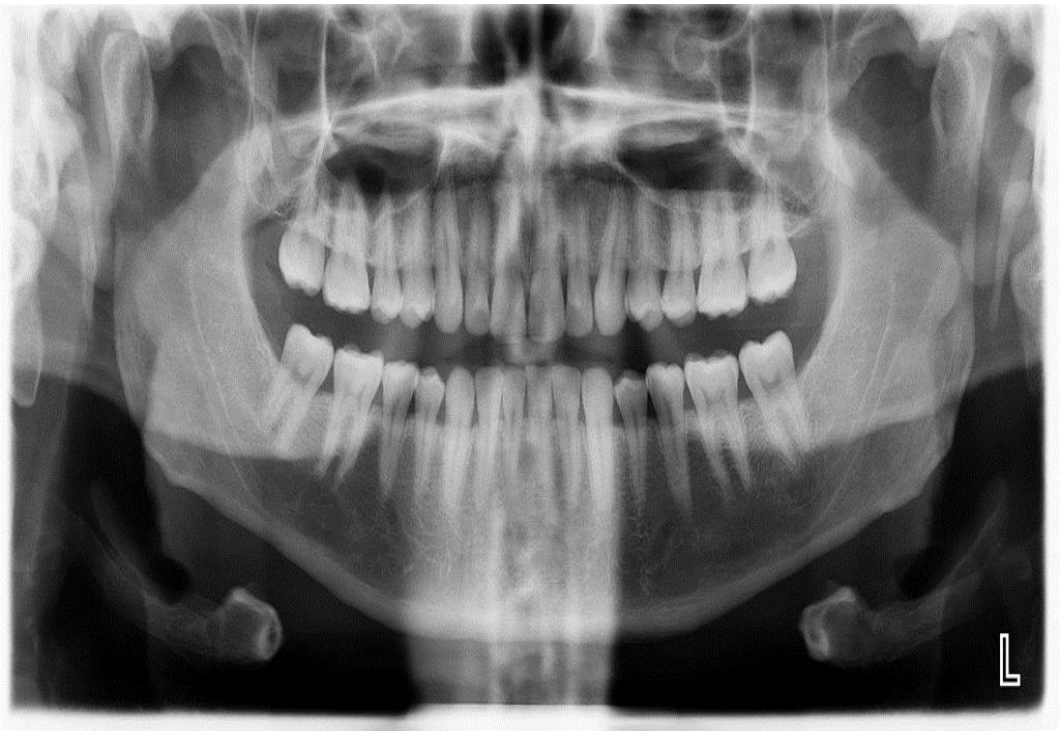


Figure 2-10: OPG

2.5.5 Case sheet and patient consent

Filled out the forms all patients after explaining the treatment process and its effects (Appendix 3) .The obtained patient's consent for the necessary treatment and a commitment was made that the researcher's responsibility was free from any consequential effects.

2.6 Criteria

To obtain the correct outputs for this study, certain criteria were applied in the selection of cases.

2.6.1 Inclusion criteria

- Pain in TMJ region and tenderness in masticatory muscles.
- Reduction in mouth opening (under 40 mm).
- No systemic and hormonal diseases.

2.6.2 Exclusion criteria

- Complicated conditions of capsular disc dislocated, injury, and tumours.
- Darker and lighter skin people.
- Over weight (Body Mass Index (BMI)($\mathrm{BMI} = \frac{\mathrm{mass(kg)}}{(\mathrm{height(m)})^2}$)

Cases of acceptable weight were selected to suit the depth of laser penetration through the adipose tissue in areas exposed to laser.

2.7 Protocol

2.7.1 Laser therapy

The patient sits on the dental chair in the position of upright; measurement of the maximum mouth painless opening is taken to begin preparing the laser device. The patient had asked to wear glasses of used laser for his safety. Operating instructions of diode laser are provided with the User Manual.

The Deep Tissue Handpiece had used at the 30 mm spot size. Adjustment power as necessary to maintain patient comfort during treatment. Place handpiece in contact to the treatment area.

The red laser beam was used as reference for center of the treatment location to position the handpiece. Treatment of the painful area had done for the duration needed.

Placing DHP over the trigger points at nearly of 3 cm above the surface. Selected parameters as in the pilot study, and started the treatment by shooting the laser by the footswitch.

Passing DHP at the location and distance for the duration of 2 seconds of laser session and repeated to all area for 5 minutes. This protocol is repeated for the other marked regions, one session every two days and for two weeks.

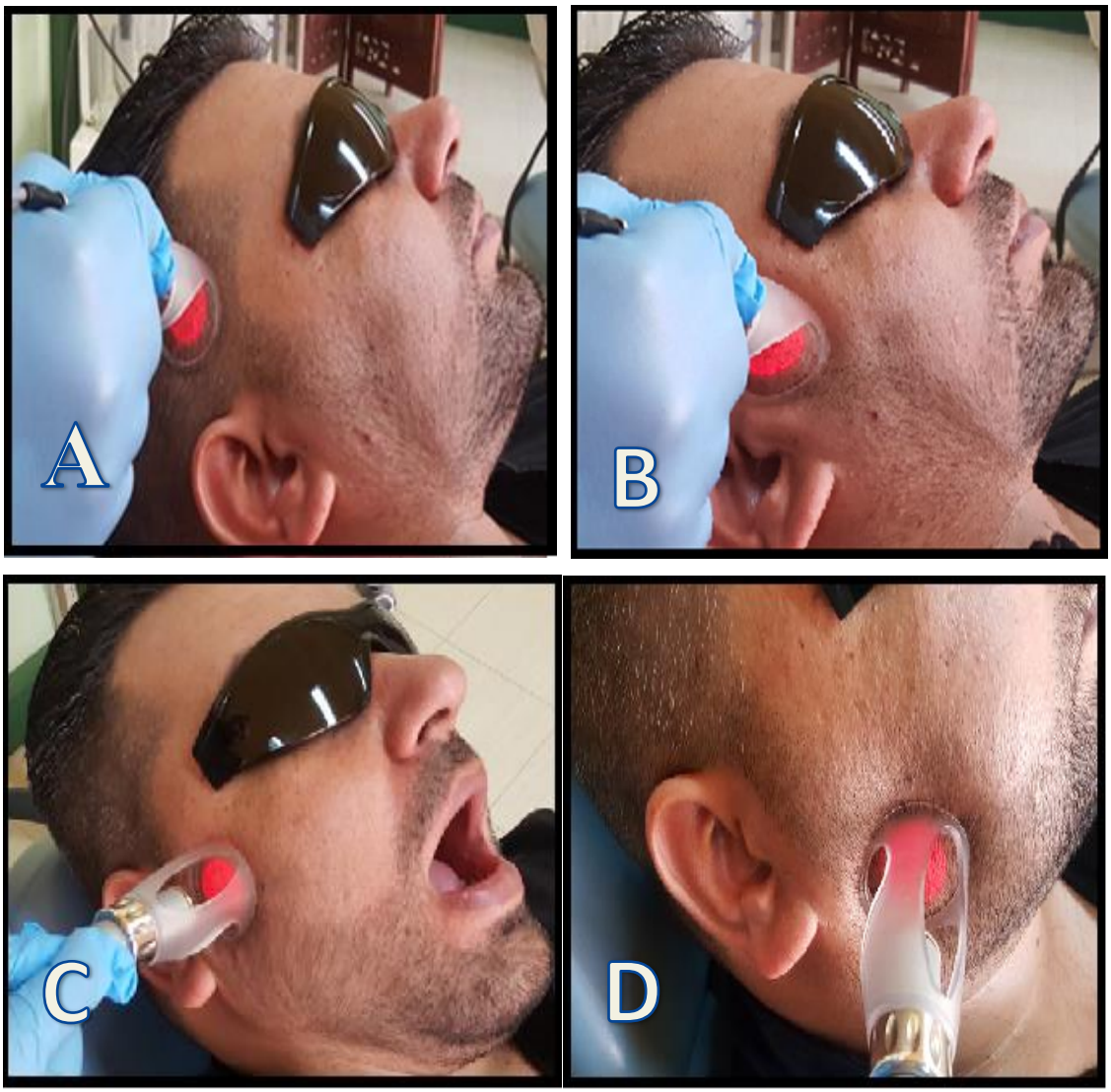


Figure 2-11: Procedure of laser therapy

A. Temporalis Muscle , B. TMJ, C. Lateral pterygoid, D. Masseter muscle

2.7.2 Pharmacotherapy

Three types of medication were used to treat the pain associated with TMD. By this study, effect of Indomethacin, Paracetamol- Orphenadrine citrate, and Diazepam have been evaluated. The dosage of each medication have illustrated in the following table;

Table 2-2: Schedule of medications used in the study [97]

Medication	**Class**	**Dosage**
Indomethacin	NSAID	50 mg /three times per day for two weeks
Paracetamol-Orphenadrine citrate	Analgesic –M. relaxant	Paracetamol 450 mg Orphenadrine citrate 35 mg 2 tab /three times per day for two weeks
Diazepam	Benzodiazepines	2 mg three times per day for two weeks

2.7.3 Follow-up

The patients were under observation and they had reviewed as following regime;

1. One day.
2. Two weeks.
3. One month.
4. Three months.

2.8 Statistical analysis

VAS is non-parametric values, while MMO is parametric values. Therefore, many tests have applied to give the appropriate outcomes. VAS results were analyzed statistically using SPSS V.20 (SPSS INC, Chicago, II, USA) for windows 7 and Excel 2010 for tables presented. The statistical analysis consists of:

1. Descriptive Statistics:

• Means.

• Standard deviations (SD).

• Standard errors (SE).

• Minimum values.

• Maximum values.

2. Inferential Statistics:

• Shapiro-Wilk’s test with skewness and kurtosis showed that for all groups, the measurement were normally distributed.

• Fisher's exact test

•Quade Test

•partial eta squared

$P \geq 0.05$ NS (Not Significant)

$0.01 \leq P < 0.05$ S (Significant)

$P < 0.01$ HS (Highly Significant)

CHAPTER THREE: Results and discussion

3.1 Results

This chapter includes the statistics of the quantitative assessment of painful area on masticatory muscles and maximum mouth opening after exposing to 940 nm diode laser and taking three medications, at different periods.

3.1.1 Distributional data

A. Method of treatment

The study consisted of 40 patients, distributed into two groups according to mode of treatment. The laser treatment group included 25 cases and pharmacotherapy on 15 cases, as described in figure 3-1:

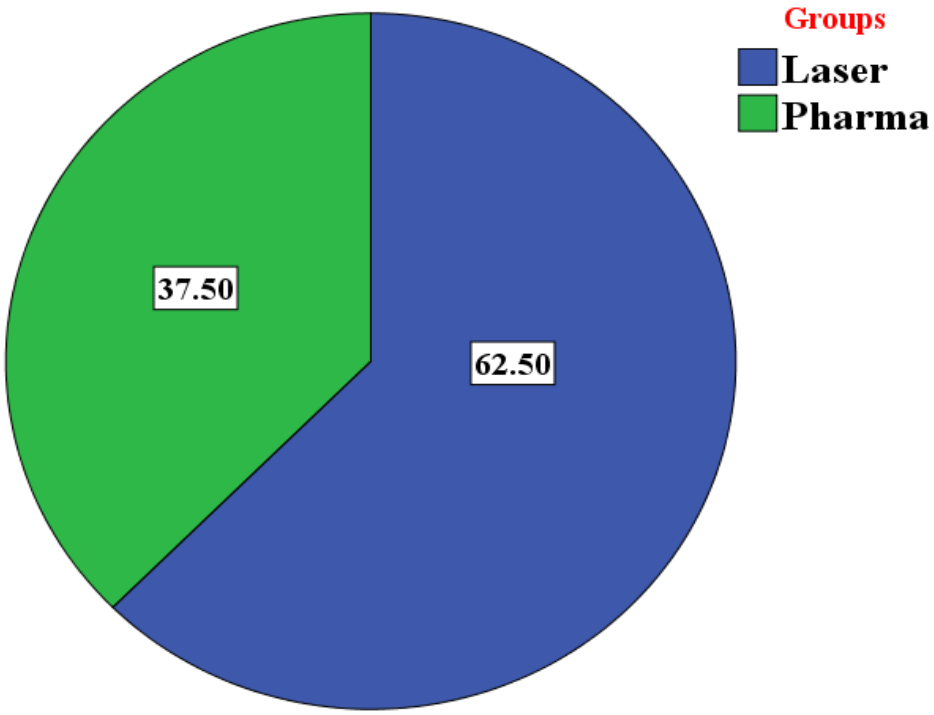


Figure 3-1: Samples distribution by method of treatment

B. Ages of patients

Selected cases have range between 25 to 54 years. They were divided to three sets. This figure illustrates that the first age group is the major between other two age groups.

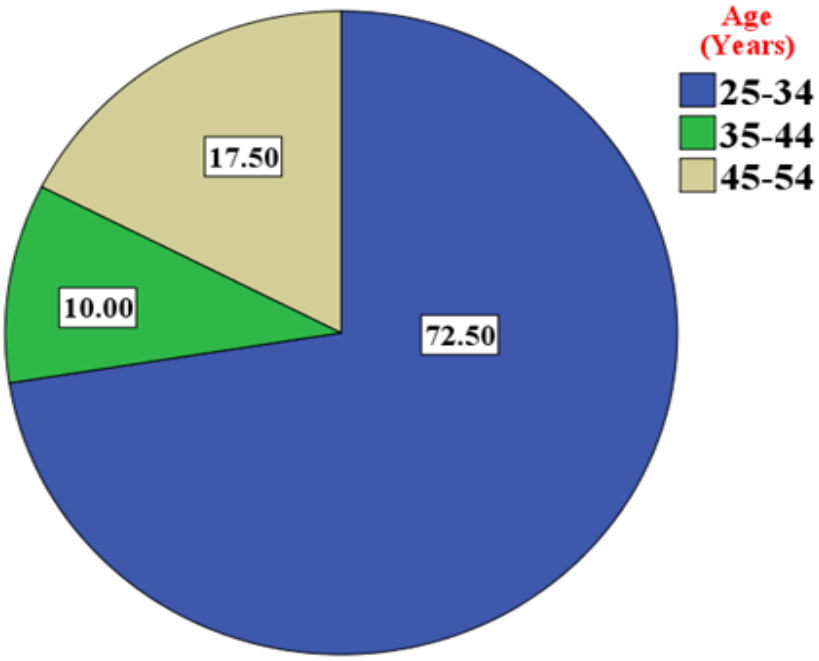


Figure 3-2: Distribution of sample according to age

C. Gender of cases

The sample contained patients of both genders, males: n=27, females: n= 13 as shown in the Table (3-1).

Table 3-1: Distribution of patients according gender and treatment

Gender		Group	
		Laser	Pharma
Males	No.	18	9
	%	66.67	33.33
	% T	45.00	22.50
Females	No.	7	6
	%	53.85	46.15
	% T	17.50	15.00

3.1.2 Association between elements of study

To exclude any factor that may affect the results of this study, we studied the relationships between the variables statistically.

A. Age and groups

The samples included in the treatment methods were divided into groups and at equal age intervals.

Table 3-2: Association between age and groups

Age (Years)		Group		F.E.P.T	P-value	Total
		Laser	Pharma			
25-34	No.	20	9	2.117	0.440 NS	29
	% within Age	68.97	31.03			100.00
	% of Total	50.00	22.50			72.50
35-44	No.	2	2			4
	% within Age	50.00	50.00			100.00
	% of Total	5.00	5.00			10.00
45-54	No.	3	4			7
	% within Age	42.86	57.14			100.00
	% of Total	7.50	10.00			17.50

There is a preference for the age range between 25 and 34 for other age groups. Table 3-2 shows that there is no significant association between age groups and treatments.

B. Etilogy and Age

The age of the cases included in the study were distributed to two sets of the causes of their illness complaint to find any factor affecting the outcome of the study.

Table 3-3: Association between ages and etiological factor

Etiology		Age (Years)			F.E.P.T	P-value	Total
		25-34	35-44	45-54			
Occlusal	No.	16	3	3	1.065	0.591 NS	22
	%	72.73	13.64	13.64			100.00
	% T	40.00	7.50	7.50			55.00
Habitual/Clenching	No.	13	1	4			18
	%	72.22	5.56	22.22			100.00
	% T	32.50	2.50	10.00			45.00

This table shows that slight preference for the occlusal cause trends to be more distributed than the habitual\clenching, also the most of the incidental causes were seen in the first age group, with no association between ages and etiological factor.

C. Etiology and tender muscles

Masticatory muscles are the main area of the study, therefore they have been tested to distinguish the more muscles had tenderness. According to their etiology in the following (Table 3-4), it demonstrates that the most tenderness finds in masseter muscle followed by Lateral Pterygoid , also the most cause was the occlusal than Habitual/Clenching with no association between tenderness in muscles and etiology of complaint.

Table 3-4: Relationship between etiology and tender masticatory muscles

Muscles	Etiology	Tenderness						P-value
		With			Without			
		No.	%	% T	No.	%	% T	
Temporal#	Occlusal	8	36.36	20.00	14	63.64	35.00	0.842
	Habitual	6	33.33	15.00	12	66.67	30.00	NS
	Total	14	35.00	35.00	26	65.00	65.00	
Masseter##	Occlusal	21	95.45	52.50	1	4.55	2.50	1.00
	Habitual	18	100.00	45.00	0	.00	.00	NS
	Total	39	97.50	97.50	1	2.50	2.50	
Lat.Pt#	Occlusal	14	63.64	35.00	8	36.36	20.00	0.564
	Habitual	13	72.22	32.50	5	27.78	12.50	NS
	Total	27	67.50	67.50	13	32.50	32.50	
Med.Pt	Occlusal	0	0	0	22	100.00	55.00	----
	Habitual	0	0	0	18	100.00	45.00	
	Total	0	0	0	40	100.00	100.00	

#=chi-square, ##=Fisher exact probability test.

D. Mouth opening & masticatory muscles

The mouth opening depends on several factors. It is very necessary in this study to explain the effect of the masticatory muscles dysfunction on the mouth opening.

Although the subjects with tenderness in muscle by calculation of P-value, the only significant difference within lateral pterygoid, since the mouth opening has affected by lateral pterygoid as shown in table 3-5.

Table 3-5: Descriptive and statistical test of mouth opening before treatment among tenderness in masticatory muscles.

Muscles	Muscles	N	Mean	±SD	±SE	T	df	P-value
Temporalis	With	14	29.90	3.93	1.05	0.236	38	0.815
	Without	26	29.60	3.72	.73			
Masseter	With	39	29.55	3.65	.59	1.716	38	0.094
	Without	1	35.90	.	.			
Lat.Ptergoid	With	27	28.88	3.57	.69	2.107	38	0.042
	Without	13	31.43	3.63	1.01			
Med.Ptergoid	With	0	.	.	.	---	---	----
	Without	40	29.71	3.74	.59			

3.1.3 Main results

The results of the pain reduction and increasing of mouth opening were obtained at varying intervals starting from a day after the beginning of treatment and the follow-up of patients to three months.

I. VAS Pain

Pain intensity was assessed on the grading of pain severity before and after each treatment session.

i.First day evaluation

The percentage of cases with pain or without pain was calculated after the 1st day to evaluate the results of treatments suggested in the study.

Table 3-6: Measurements of pain after 1st day of treatment

		Groups		Chi-square	Df	P-value	Total
		Laser	Pharma				
With	No.	11	13	7.111	1	0.008 HS	24
	% within Group	44.00	86.67				60.00
	% of Total	27.50	32.50				60.00
Without	No.	14	2				16
	% within Group	56.00	13.33				40.00
	% of Total	35.00	5.00				40.00

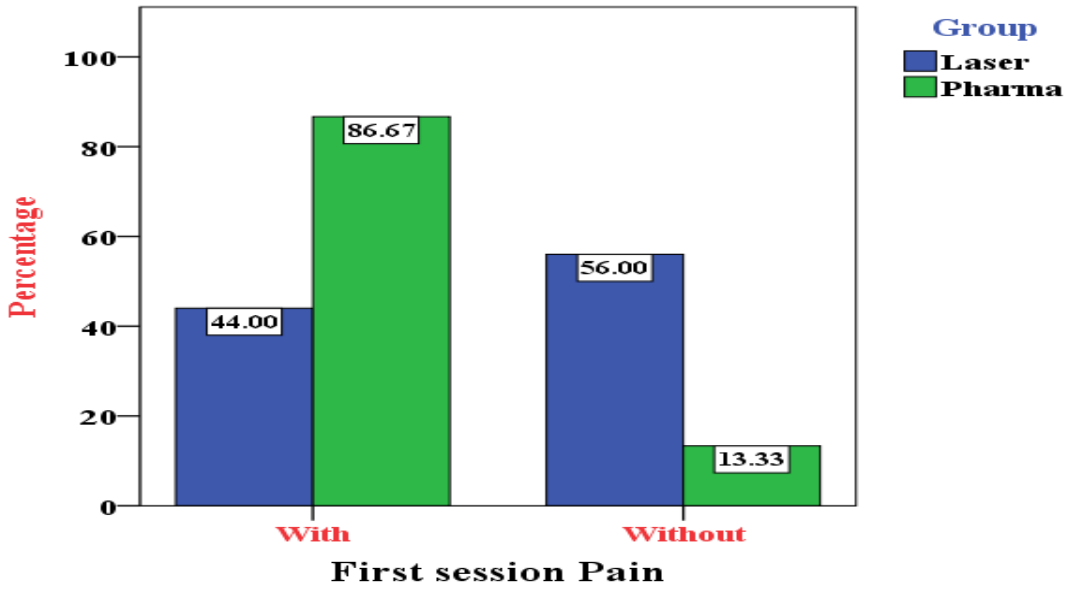


Figure 3-3: The percentage of cases with or without pain after one day of treatment.

Percentage of cases with pain in pharmacotherapy group is more than those in laser one with highly significant association between group and pain (table 3-6) and (figure 3-3).

ii. Pain scores at end of treatment

Table (3-7) give the mean and median pain in each of the studied groups in all study periods.

Table 3-7: Descriptive and statistical test of pain scores among groups and periods.

Group	Statistics	Before	After	1month follow up	3months follow up	Quade test	Sig.
Laser	Mean	6.68	0.56	0.68	0.92	47.197	0.000 HS
	±SD	1.03	0.77	0.75	0.76		
	Median	7.00	0.00	1.00	1.00		
	Min.	5.00	0.00	0.00	0.00		
	Max.	8.00	2.00	2.00	2.00		
Pharma	Mean	6.67	2.00	1.80	2.20	25.304	0.000 HS
	±SD	1.18	1.00	0.68	1.08		
	Median	7.00	2.00	2.00	2.00		
	Min.	5.00	0.00	0.00	0.00		
	Max.	8.00	4.00	3.00	4.00		

Analysis of results during treatment periods and follow-up shows how pain was reduced significantly (figure 3-4, figure3-5).

iii. Follow-up of patients after one month (Pain scores)

The reduction in pain levels was obvious in two groups; laser was more effective during the entire study period. Improvement of patients' condition improvement remains best in the laser group.

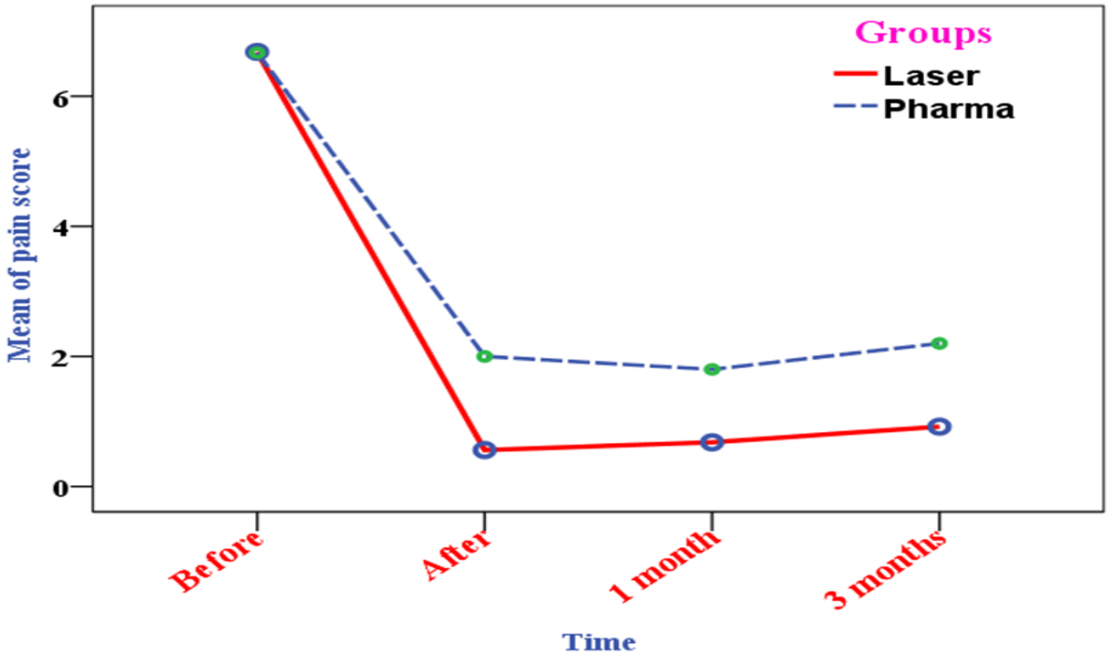


Figure 3-4 :The mean of pain score in two groups after the treatment

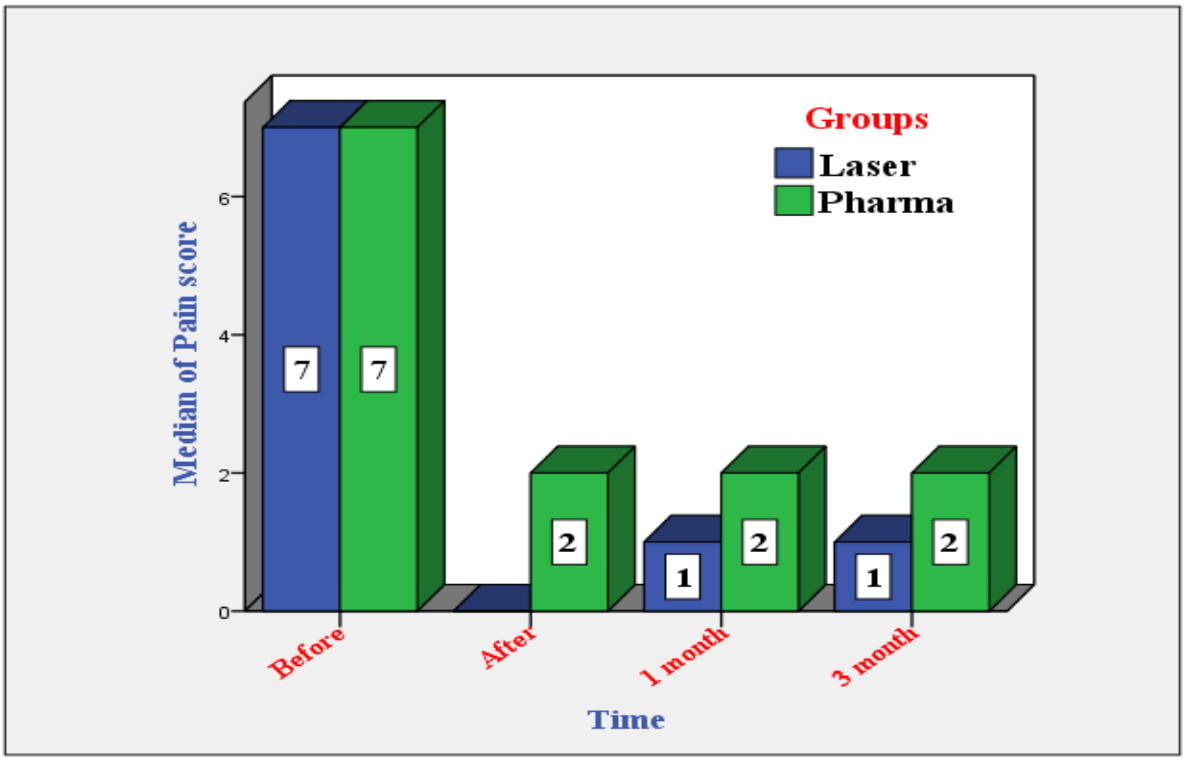


Figure 3-5: Median of pain score before, after treatment, and follow up

iv. Follow-up of patients after three months (Pain scores)

Recurrence of symptoms (pain and mouth opening limitation) in some cases was higher after third month of follow-up of patients in the pharmacotherapy group (figure 3-4).

To assess the pain reduction, the changes within each group between the periods of this study had estimated. Comparing the VAS for pain between groups at each period separately to see the effect of treatment on the pain, within groups (Table 3-8) (Multiple comparisons of Pain between periods within groups).

Table 3-8: Test the **variance analysis of the samples associated with the pain factor values throughout the study periods**

Groups	Time	Before	After	1 month	3 month
Laser	Before		0.000	0.000	0.000
	After treatment			0.383	0.0017
	1 month				0.0198
Pharma		**Before**	**After**	**1 month**	**3 month**
	Before		0.000	0.000	0.000
	After treatment			0.244	0.289
	1 month				0.029

Red color: Value < 0.05

The results had analysed at close intervals and compared with each other to determine the accurate degree of improvement in treatment. Pain in laser groups is better than pharma groups with significant difference between them at most periods.

1. **Pharmacotherapy group:** In the follow-up period between one month and three months of treatment, the results had a significant difference.

2. **Laser therapy group**: Decreasing in pain level had found to be gradually well within time especially after treatment period with highly significant difference, when using multiple comparisons, all results were found to be highly significant except one period (between the end of treatment and one month of follow-up).

II.Mouth opening

The mouth opening is an important indicator of the functional integrity of the TMJ. Cases in both groups have been subject to several periods of observation.

i. First day evaluation

The mean of the mouth opening had calculated after one day of the treatment on the all samples of both groups (Table 3-9).

Table 3-9: Comparison of mouth opening in different statistical values between the laser therapy group and pharmacotherapy group.

Groups		MO before	MO after 1st day	Wilcoxon rank#	Sig.
Laser	Minimum	24.500	26.300	**4.376**	**0.000 HS**
	Maximum	35.900	45.000		
	Mean	**29.624**	**36.154**		
	±SD	3.631	6.174		
	Median	**29.600**	**37.300**		
Pharma	Minimum	24.700	25.300	**3.413**	**0.001 HS**
	Maximum	36.000	40.950		
	Mean	**29.847**	**31.760**		
	±SD	4.054	4.815		
	Median	**29.100**	**31.700**		

The significant difference in Wilcoxon sign rank were preferential for the laser therapy group is present. The Wilcoxon signed-rank test is a non-parametric statistical test used to compare two related samples, matched samples, or repeated measurements on a single sample to assess whether their population mean ranks differ [98].

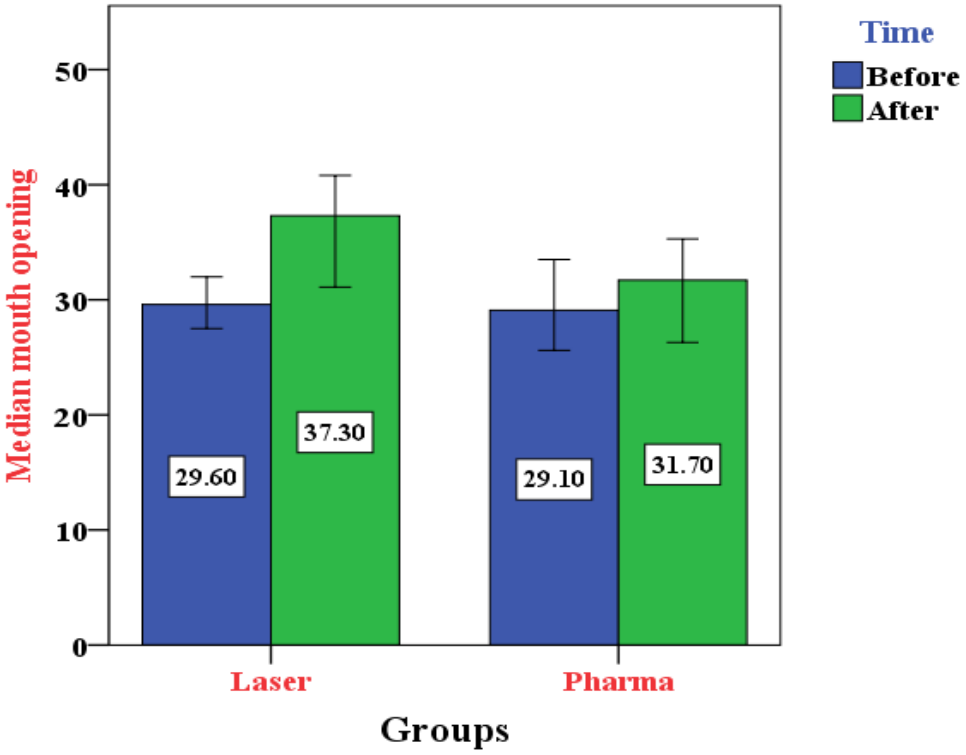


Figure 3-6: Median mouth opening after one day of treatment

ii. Evaluation at end of treatment (2 weeks)

By using model of increasing mouth opening with repeated measure, the main effect of time has a highly significant effect on mouth opening while the interaction between time and group has no effect (table 3-10).

iii. Follow-up of patients after one month

Many patients with a decrease in the non-painful mouth opening were observed (table 3-10).

iv. Follow-up of patients after three months

The number of patients with reduction in the non-painful mouth opening were increased (table 3-10).

Table 3-10: Statistical test of treatment groups within each periods on maximum mouth opening.

Time	Group	Min.	Max.	Mean	±SD	Time	
						F	Sig,
Before	Laser	24.50	35.90	29.62	3.63	675.741	0.000 HS
	Pharma	24.70	36.00	29.85	4.05		
After treatment	Laser	40.10	53.20	46.00	4.01		
	Pharma	40.20	51.00	45.08	3.02		
1 month	Laser	40.10	53.00	45.40	3.68		
	Pharma	40.50	50.00	44.66	2.58		
3 months	Laser	40.10	52.00	44.62	3.33		
	Pharma	41.00	49.30	44.26	2.41		

Previous analyses may be insufficient to give a real evaluation of the treatments effect on maximum mouth opening in both groups. Results in this table show the amount of increase in the mouth opening in both groups after treatment then it will decrease with highly significant change.

Multiple comparisons of mouth opening between periods within groups

1. Laser therapy group ; the first time period has highly significant difference with others, while the second and third ones have significant difference with others except between second and fourth one has highly significant difference (table 3-11).

2. Pharmacotherapy group; the first time period has highly significant difference with others, while when compare other time periods with each other have no significant difference (table 3-11).

Table 3-11: Test the variance analysis of the samples associated with the means of mouth opening values through study periods.

Group	factor1	Mean	SE	F	P-value	**Partial eta square**	Multiple comparisons(Bonferroni)	
Laser	Before[1]	29.62	.76	479.298	0.000 HS	**0.976**	1 X2=0.000	2 X3=0.018
	After[2]	46.00	.73				1 X 3=0.000	2 X 4=0.001
	1month[3]	45.40	.66				1 X4=0.000	3 X 4=0.022
	3months[4]	44.62	.60					
Pharma	Before[1]	29.85	.98	253.753	0.000 HS	**0.955**	1 X2=0.000	2 X3=0.564
	After[2]	45.08	.95				1 X 3=0.000	2 X 4=0.387
	1 month[3]	44.66	.86				1 X4=0.000	3 X 4=1.00
	3months[4]	44.26	.78					

v. Efficiency of treatment methods

The outcomes of the study for mouth opening after three months were very close. Therefore, final assessment was made to compare the results of the two groups. The mean efficiency of the two groups for the mouth opening had calculated, and it was higher with laser therapy (table 3-12).

Efficiency (change percentage) =100*(after-before)/ before [99]

Table 3-12: Descriptive and statistical test of efficiency in mouth opening among groups.

Laser	Minimum	2.73	P-value
	Maximum	41.02	0.000 HS
	Mean	21.6420	
	±SD	11.49410	
	Median	25.3482	
Pharma	Minimum	0.92	0.000 HS
	Maximum	17.34	
	Mean	6.3082	
	±SD	5.50213	
	Median	3.4364	

The median efficiency of maximum mouth opening with laser therapy group more than that in Pharmacotherapy group with highly significant difference as findings in figure 3-7 .

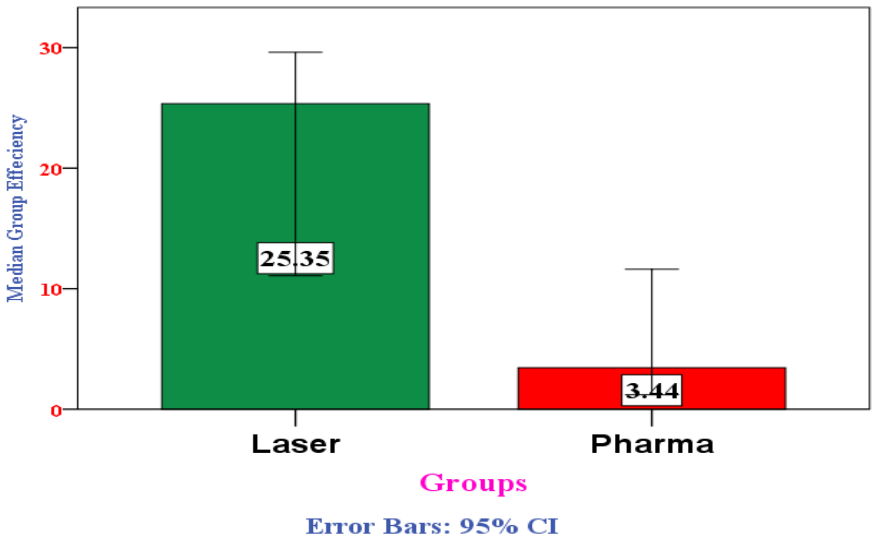


Figure 3-7: Median group efficiency of mouth opening

III.Side effects

Several side effects had observed during treatment, follow-up, and each according to their group.

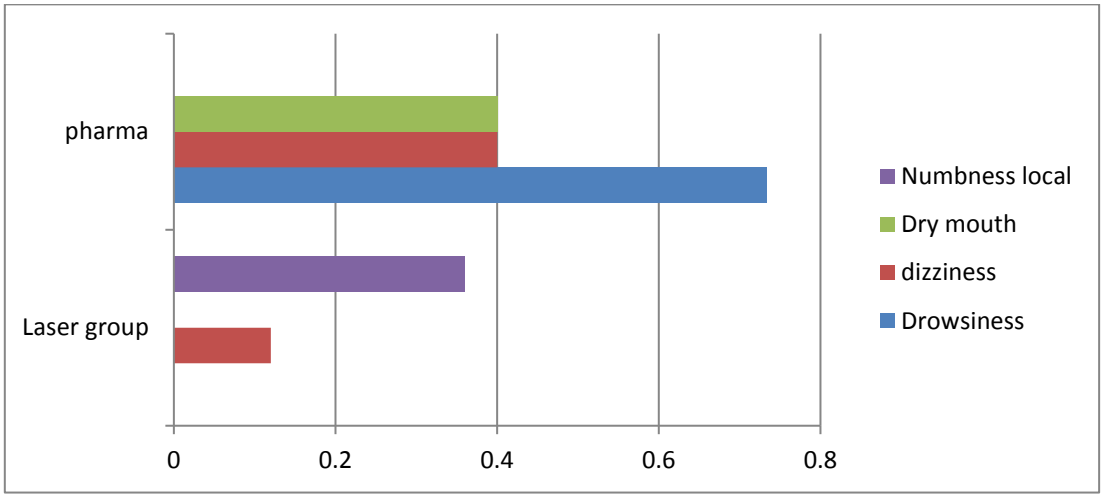


Figure 3- 8: Mean of the most common side effects following the treatments

the lowest number of patients who suffered from multiple side effects were in the laser therapy group. .

3.2 Discussion

The condition of temporomandibular pain of myogenic origin is often referred patients to dental clinics. In this study, the highest proportion of patients with TMD is among people aged 25–34 years. Using of non-invasive, safe, and more comfortable methods of treatment with reduced morbidity is our aim. There are two kinds of LLLT effects:

1. Photomiomodulation

laser therapy effects on a proteins of mitochondria and elevate of ATP production and decrease oxidative stress (cytochrome c oxidase), thus mitochondrial activities will reduce inflammation [100].

2. Analgesic effect

High power density more than 400 mW/cm², minify ATP in fibres A and B, thus lead to neural blockade last up to approximately 24 hours [100].

Last experiments explain the response of living cells to photon energy. The study on repairing of tissue explained the intra-tissue changes at laser exposure. This concept is the primary effect to laser bio-activation [101].

The primary tissue response to laser beam is local; occurring of vasodilatation and increased blood circulation; increasing lymphatic discharge; elevation macrophage work, and an improved metabolism in damaged cells [102].

LLLT causes vasodilation by triggering the relaxation of smooth muscle associated with endothelium. This vasodilation increases the availability of oxygen to treated cells, and allows for greater traffic of immune cells into tissue. These two effects contribute to accelerate healing. NO is a potent vasodilator via its effect on cyclic guanine monophosphate production, and it has been hypothesized that LLLT may cause photodissociation of NO, not only from CCO, but from intracellular stores such as nitrosylated forms of both hemoglobin and myoglobin, leading to vasodilation [102,103].

The secondary effect by accumulative photo-products of beam in the circulatory blood or/and lymph. Aggregation of prostaglandins, enkephalins and endorphins in plasma have a role in pain relief [102,103].

.

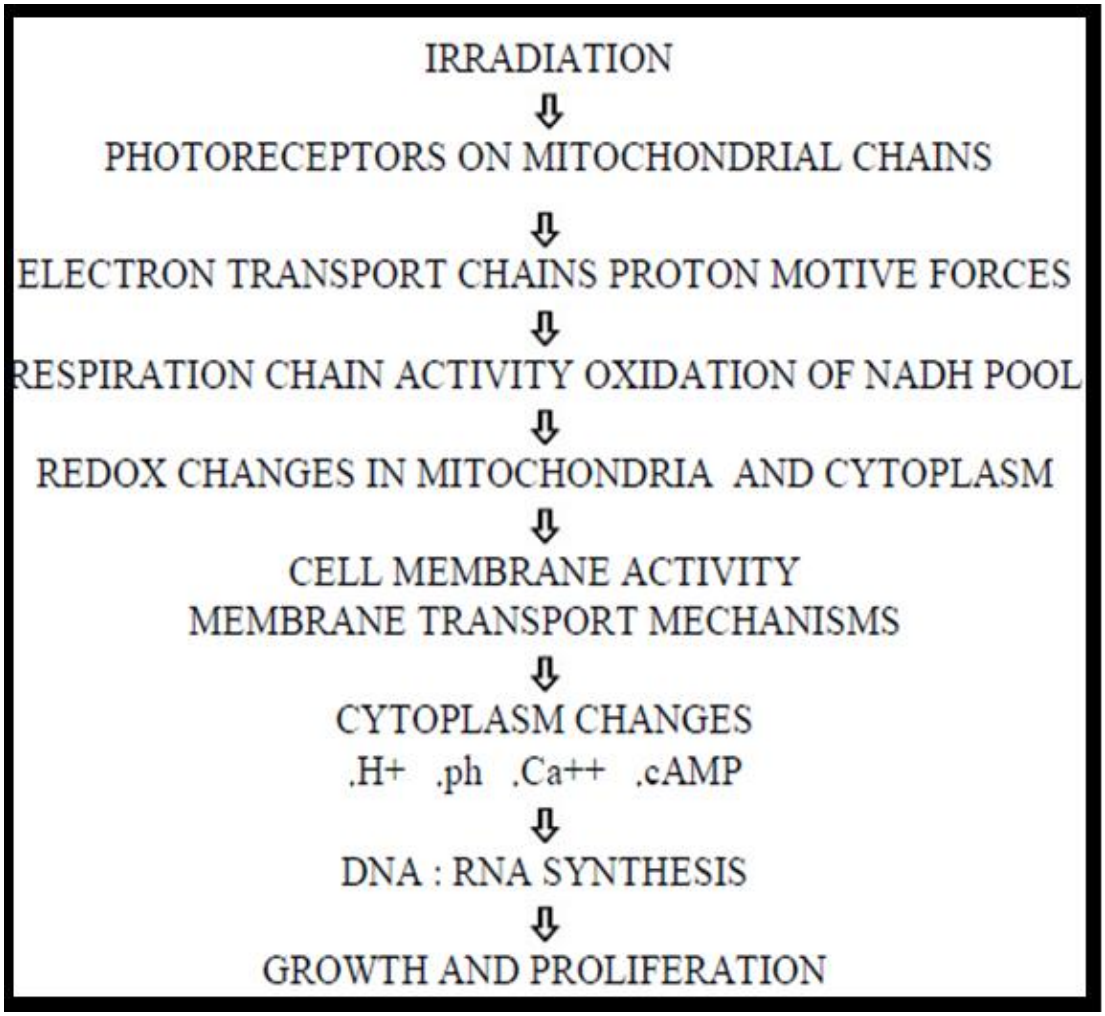


Figure 3-9: Cellular response to laser irradiation [102].

3.2.1.1 VAS pain

The standard way of treating myofascial pain in dental clinic is a pharmacotherapy, while the laser therapy is the most desirable method, which produces the fastest effect of pain relief. Laser is better choice than medications, which may have side effects on patient.

The Visual Measurement Scale (VAS) recorded the scores of pain in all patients before starting treatment, after two weeks when the treatments has completed, and follow up for three months. .

In some studies, results show that LLLT can significantly reduce inflammation by decreasing cyclooxygenase-2 (COX-2) expression, and inhibition of edema formation, since laser therapy has potential to become a new and safer nondrug alternative to NSAIDs. Laser therapy is also able to increase the number of newly formed vessels [104]. .

Analgesic effects of laser on myogenic dysfunction are due to β-endorphin, discharge. Threshold of pain, lymphatic, flow, blood supply and muscle relaxation along with decrease of bradykinin and histamine release with edema [105].

3.2.1.2 Mouth opening

The results and analysis of the statistical data also showed improvement in the mouth opening in all groups after one month and three months closely. The laser group showed greater improvement than the pharmacotherapy group for opening.

The relaxation effect on muscle spasm and the level of pain significantly helped to return the mechanism of opening the mouth better. However, the presence of a number of psychological and emotional factors have affected a slight decline in some cases.

In this study deep tissue handpiece diode laser (940 nm, 4W, 2 second / trigger point, and 0.566 W/cm^2), shooting for 5 minutes to one side, continuous and defocused beam was used in TMJ region at three points, including three different area for extraoral regions. These applications were made in three times a week for two weeks for each patient. With such parameters there were not studies had achieved. The aim of this application protocol was to reach most near parts of the TMJ with minimum patient discomfort.

3.2.2 Comparison with studies of laser therapy

There is still no consensus on dose of irradiation and number of laser sessions.

A. Age groups of patients

In this study, the average age in this study was (34) years, the majority of them were young. Young people suffer from psychological stress more than other ages, after a period of time either healing occurs when appropriate treatment is applied or that infection occurs with age, thus the rate of complaint is reduced by exposure to TMDs [106].

The results of this study are in agreement with those of other investigators including Martins-Júnior and Mortazavi. Other investigations had achieved by Lipton and Glass & Glaros, the most common age for onset of this disorders is between 20-40 years old [107,108].

This study agree with Minghelli, he demonstrated patients with these disorders were young people by range (68%). Occurrence of TMD in these ages could be triggered by emotional stress [109].

B. Effectiveness of treatment protocol

The application sites are through the overlying skin of the masseter, temporalis, and pterygoid muscles. Many studies report that the use of LLLT in TMD, could be effective while the others report that its effectiveness is not fully proven. This study disagree with Emshoff and De Abreu Venancio, they reported that there was no relief in TMJ pain after the application of LLLT [110]. Petrucci reported that LLLT is inadequate in reducing TMJ pain [111].

Many studies agree with this study, since they reported that LLLT application is an effective therapy and can be used in the TMD patients. The studies of Mazzetto, Çetiner, and Venezian, reported that patients were followed up to 30 days after the last sessions of laser application.

Çetiner and Venezian reported that the reduction in pain continued to be statistically significant in this period [112, 113].

Despite these results, Mazzetto reported minimum sensitivity to palpation was gone in the last laser application session. Lassemi followed up the patients for one year and documented relevant outcomes in relief pain [114].

It was agree with the studies of Kulekcioglu, Kahraman, Yücetaş, Fikácková, Cunha, Santos, and Carvalho worked on the affected area by laser and on trigger points. The outcomes of Kulekcioglu,Venancio, Camparis; Çetiner, Kahraman ; Fikácková, Mazzetto, Carrasco, Cunha, Lassemi, Santos, and Venezian, et al. reported that an infrared wavelength are the optimum lasers due to deeper penetration. It was agree with last studies, laser had varied from 780 to 980 nm [115,116].

3.2.3 Comparison with studies of Pharmacotherapy

The management of TMJ pain by medications was done after studying the best possible effects of each drug alone and not interfere with the other medicine. There is no scientific paper or research in which used the three drugs combined in the treatment of these disorders.

A. Effectiveness of pharmacotherapy

NSAIDs are effective medicine on the treatment of mild and moderate musculoskeletal inflammation. Muscle relaxants reduce contraction of skeletal muscle. When muscle tone is decreasing without altering of motor action and depressing synaptic reflex [117,118].

In this study, the suitable effects were seen when the concentration of medicine was optimal in the body, and the therapeutic effects of the medicines reduce the symptoms reappeared [123].

Tsuga observed that more than 80% of patients who used muscle relaxant had VAS reduction [124].

Harkins concluded That more than 70% of the patients with NSAID had reliving in facial myalgia [125].

Pharmacotherapy directed to the pathophysiology of disorders. The reviews of pharmacotherapy of TMDs need to work more to find mechanisms that targeted by pharmacological agents [126].

Using of Gabapentin in myogenic pain shows a relief effect on pain but within a short time [127].

The most of anti-inflammatory medicines are useful with moderate and severe conditions, by blocking of phospholipase lead to decreasing of prostaglandins [128,129].

Dionne state that patients with Valium observed reduction in sever jaw pain [130].

B. Side effects

Benzodiazepines were undesired because of drowsiness, confusion, and impaired coordination. The tolerance to benzodiazepines lead to psychological dependence if these medicines are taken more than limited period.

The GI bleeding related to chronic NSAID administration medicines for TMD has caused to made alternative option of therapy. Opioid is effective to treat moderate and severe pain is well established [132,133].

Gastric erosion is caused by NSAID, that lead to ulcers and gastric Bleeding, especially among the elderly [134].

Myorelaxants may cause strong sedation. Taking these drugs At bedtime due to drowsiness. [135]. Dizziness and somnolence have most frequently reported with patients who take these medications. [136].

C. Intake period

To reach an optimal effect, the medications should be taken for two weeks as minimum [137].

Muscle relaxants are taken for a week. The patients were observed with recurrence of symptoms during follow-up, the advice was repeating the regimen to another week [138].

NSAIDs effect best when taken for a period of (2-4) weeks [139]. Indomethacin overdose signs include serious side effects. Treatment should continue until symptoms of inflammation have been controlled; usually 7 to 14 days [140].

3.2.4 Comparison between laser therapy and pharmacotherapy

the results is agree with Marini study that postulated that pain severity of muscles masticatory function improved in all patients who received LLLT and it has been more efficient in the treatment of pain caused by TMJ disorder compared to NSAID [141].

Another research agree with study, which states the improvement had observed in maximum painless mouth opening in laser group. In NSAID group, significant increase in mouth opening were comparable to laser therapy [142].

Findings of this study summarized that there were differences between the laser and the pharmacotherapy cases in degree of effectiveness in reducing the level of pain and increase mouth opening in patients with myogenous origin of TMDs.

The reason for obtaining close results between the two modes of treatment during after three months, the mechanisms are same in treating such cases ; pain relief, muscle relaxation, and anti-inflammatory effects.

3.3 Conclusion

1. Regarding the VAS measurements for main groups, diode laser 940 nm with 4 W and continues irradiation with defocusing mode, it is totally acceptable and it has no harmful effect, while pharmacotherapy causes slight side effects but is considered within safety limits.
2. High significant improvement of pain relief at first session, also during the treatment sessions, since laser therapy is a significant method of treatment for mouth opening limitation.
3. Assessments of the maximum mouth opening without pain, showed no significant difference among groups after three months. Results are relatively better for laser therapy group.
4. Laser is effective in the treatment of acute, and mild musculoskeletal conditions, and it has recommended for of such disorders.

3.4 Suggestions for Future Studies

1. Further studies of application of the laser therapy on larger number of samples and follow-up for longer periods (one year).
2. Further study for comparing of laser effects versus other modes of treatments like Botox.
3. Studying the laser therapy on different skin colors (different races), and testing the elevation in temperature with each case.
4. Studying the effectiveness laser therapy in the treatment myogenic origin of TMJ disorders using different energies from the energy used in this study.

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Appendix (1) Instructions about using laser system

Clinical Use

- Scar tissue has been associated with poor circulation and reduced cooling through heat transport by blood; power settings may have to be reduced to avoid overheating.
- Patients with tender or sensitive skin may be hypersensitive to heat; reduce power as necessary to ensure comfort during treatment.
- Patients with swelling and/or inflammation may be sensitive to heat; reduce power as necessary to ensure comfort during treatment.
- Do not treat open wounds.
- Muscle tissue closer to the skin surface may experience a higher absorption of heat; carefully monitor skin temperature and reduce power as necessary.
- Excessive fatty tissue is known to transmit heat without much attenuation; reduce power.
- Different implant materials will respond differently to laser energy and heat; be aware of any implants and their location; avoid direct exposure to laser energy or heat at the site of the implant.
- Avoid treatment of sites that have tattoos.
- Do not apply ointment, creams, lotions or heating lotion patches at, or in close proximity to, the treatment area.
- Do not apply therapies prior to treatment that could change body temperature, such as ultrasound, ice/heat pack, electrical stimulation, or heating patches.
- Do not apply treatment over articles of clothing.

Section 1: Deep Tissue Handpiece Description

The Deep Tissue Handpiece is intended for use with the BIOLASE diode laser therapeutic diode laser system. The BIOLASE diode laser is a prescription device intended for use by a licensed medical practitioner.

Section 2: Installation

1) Remove Red Dust Cover from Deep Tissue Handpiece.
2) Slide handpiece over monocoil shaft until it clicks into place.
3) Place protective cover over the adjustable spacer.
4) Loosen the Lock Ring and set the spacer at the 30 mm spot size detent location. Tighten the Lock Ring.
5) Place handpiece into the handpiece holder. To remove handpiece, press and hold the buttons on the side of the shaft and pull handpiece away from shaft.

Section 3: Operation

Safety and operating instructions of BIOLASE diode laser are provided with the User Manual. The same instructions apply to the Deep Tissue handpiece. The Deep Tissue Handpiece is indicated for use at the 30 mm spot size.

1) Set the spot size to 30 mm:

   Loosen the lock ring and slide spacer to the 30 mm spot size detent location. Tighten the lock ring to prevent spacer from moving during treatment.

2) Select appropriate laser parameters:

   To select power and exposure time, refer to Section 6 - Clinical Settings. Adjust power as necessary to maintain patient comfort during treatment.

3) Perform treatment:

   A) Set the system into Ready mode, by pressing the READY button.

   B) Place handpiece with protective cover in contact to the treatment area.

   C) Use the red laser beam as reference for center of the treatment location to position the handpiece.

   D) Press the footpedal to activate the infrared laser. A beeping sound is produced to alert the user that the laser is firing.

   E) Treat the area for the duration needed.

   G) Check with the patient periodically to ensure comfort during use. Reduce power when patient is reporting discomfort.

Section 4: Recommended Use

There are four main variables that impact the safety and effectiveness of pain therapy procedures:

1) Power output
2) Distance from the skin surface
3) Range of movement of the handpiece
4) Patient skin type

Safety and effectiveness are described by elevating the skin temperature in the treatment area utilizing the settings recommended in this manual. Use personal clinical judgment with consideration of the Fitzpatrick Skin Type Scale when selecting procedure parameters; monitor the patient and adjust the settings as necessary for effectiveness and patient comfort.

Appendix (2) Patient consent

تصريح لقبول المريض للدخول ضمن عينة البحث العلمي بعنوان:

فعالية ليزر الدايود 940 نانومتر في معالجة اضطرابات المفصل الفكي الصدغي ذات المنشأ العضلي

اسم المريض .....رقم الحالة..... :

العنوان ... .تاريخ الميلاد..... :

أنا الموقع أدناه السيد(ة :)أوافق على أن أكون أحد أفراد عينة البحث العلمي المذكور أعلاه والذي يجرى في قسم التطبيقات الحيوية و الطبية في معهد الليزر للدراسات العليا جامعة بغداد وذلك بعد اطلاعي من الباحث على طبيعة البحث المجرى والإجراءات المطبقة في سياق المعالجة بشكل تفصيلي.

بغداد في .....

اسم وتوقيع المريض : **توقيع الباحث:**

Appendix (3)

Case sheet

University of Baghdad
Institute of Laser for postgraduated studies
Department of Biomedical Applications

جامعة بغداد
معهد الليزر للدراسات العليا
قسم التطبيقات الحيوية والطبية
نموذج مراجعة

Oral and Maxillofacial Surgery Associates Patient Health History Form

Patient's Name .....Date .....Age .....Sex.....

Address..... Occupation .....Tel No.....

Chief Complain (in patient's own words) .....

.....

History of present Illness (HPI).....

.....الجنس.....العمر.....التاريخ..... اسم المراجع
.....العمل ..... رقم النقال..... العنوان
.....الشكوى.

..... تاريخ الشكوى

Behavior O constant O intermittent

نوع الالم مستمر متقطع

Clinical Examination

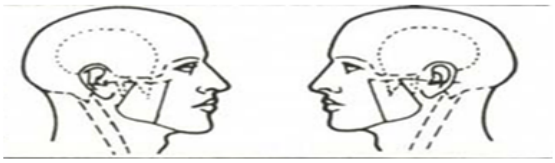
A.Extra Oral Examination

Tempromandibular Joint symptoms (TMJ palpation)

A. Pain during palpation or mouth opening

page (1)

B. Area to which pain radiates



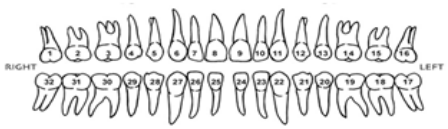
C. Pain of associated muscles

Muscles	Right	Left	Primary or secondary
Masseter palpation			
Temporalis palpation			
Lateral pterygoid muscle			
Medial pterygoid muscle			

D. Opening of the mouth .....

Intra Oral Examination

A. Oral Hygiene and breath .....B. Oral lesions .....



M	Missing Tooth	
F	Filling	
C	Carious tooth	

Page (2)

Instructions الارشادات

1. Avoid extreme jaw movements

2. Don't rest your chin on your hand

3. Eat soft food that does not need much chewing. No chewing gum.

Follow up weekly and for three months

1.تجنب فتح الفم بصورة كبيرة اثناء الصراخ او الاكل او التثاؤب

2 . لا تضغط بالكف على اسفل الفك السفلي

3 . الابتعاد عن المأكولات الصلبة و العلكة

المتابعة اسبوعيا ولمدة ثلاث اشهر

Visit	Date	Pain Score	Mouth opening	Evaluation
1				
2				
3				
4				
5				
6				

الخلاصة

مقدمة : ان اضطرابات المفصل الصدغي الفكي ذات المنشا العضلي هي الاضطرابات الأكثر شيوعا للمرضى الذين يحتاجون العلاج خلال زيارة عيادة الأسنان. العوامل الرئيسية المسببة المؤدية إلى اضطراب المفصل الصدغي الفكي هي سوء الإطباق، والرضوض ، والإجهاد العاطفي والنفسي، والسكتة الدماغية النشطة . تم اقتراح أساليب مختلفة من العلاجات لمعالجة هذه الاضطرابات، بصورة عامة العلاج الدوائي ، والعلاج الطبيعي، والعلاج النفسي، والوخز بالإبر، و جبائر الاسترخاء، والبوتوكس , ومؤخرا العلاج بالليزر. جميع أنواع الليزر في طب الأسنان ترفع درجة الحرارة في الهدف المعني عن طريق التفاعلات الحرارية الضوئية، و ضمن حدود السلامة للانسجة ويساعد على تخفيف تشنج العضلات وتمكينها من العمل بشكل طبيعي.

الهدف من الدراسة : تقييم كفاءة ليزر الدايود 940 نانومتر في معالجة اضطرابات المفصل الصدغي الفكي ذات المنشأ العضلي

المواد والطرق: شملت الدراسة (40) مريضا تم تشخيصهم مع الم في منطقة المفصل الفكي الصدغي و قصور في فتحة الفم إلى مجموعتين. تلقت المجموعة الاولى إندوميتاسين وسيترات أورفينادرين و باراسيتامول ود يازيبام لمدة أسبوعين و تلقت المجموعة الثانية العلاج بليزر الدايود 940 نانومتر بست جلسات في أسبوعين. وقد تم قياس شدة الألم من خلال مقياس التماثلية البصرية والحد الأقصى لفتح الفم غير المؤلمة. حيث تم تقييم النتائج قبل وبعد العلاج ، ولمدة ثلاثة أشهر.

النتائج: هناك فرق ملحوظ بين مجموعة الليزر ومجموعة العلاج الدوائي ($P < 0.05$) قبل وبعد العلاج. أظهرت المجموعة التي عولجت بالليزر فتحة فم أفضل، وانخفاض في مستويات الألم أكثر من المرضى الذين عولجوا بالعلاج الدوائي، و خاصة بعد بعد يوم واحد من جلسة العلاج ، مع عودة علامات وأعراض الاضطراب لبعض المرضى في مجموعة العلاج الدوائي بعد ثلاثة أشهر.

الاستنتاج : ادى العلاج بالليزر الى تحسن ملحوظ في فتحة الفم و شدةالألم لدى المرضى الذين يعانون من اضطرابات عضلية المنشأ. وأظهر ليزر الدايود نتائج أفضل في وقت أقصر وأكثر أمانًا وفعالية من الأدوية.

وزارة التعليم العالي والبحث العلمي

جامعة بغداد

معهد الليزر للدراسات العليا

معالجة اضطرابات المفصل الفكي الصدغي العضلية بواسطة ليزر الدايود (940) نانومتر و العلاج الدوائي

(دراسة مقارنة)

رسالة مقدمة الىمعهد الليزر للدراسات العليا/ جامعة بغداد

/ لاستكمال متطلبات نيل شهادة ماجستير علوم في الليزر /طب الاسنان

من قبل

انس عدنان ياسين الشماع

بكالوريوس طب وجراحة الفم والاسنان

بإشراف

الاستاذ الدكتور تحرير نزال الدليمي

1438 هـ 2017 م